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SEED TREATMENT FOR BLACK-LEG DISEASE OF CRUCIFERS

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TECHNICAL BULLETIN NO. 137

SEED TREATMENT FOR BLACK-LEG DISEASE OF CRUCIFERS[1]

E. E. CLAYTON

ABSTRACT

This reports experiments with seed treatments for black-leg (*Phoma lingam* (Tode) Desm.) on cabbage and brussels sprouts. The work was conducted on Long Island during the period 1922 to 1927, inclusive.

Records show that seed infection by black-leg in the Long Island seed-growing district is common some years and scarce or absent other years. This has been found to be due to the fact that the seed pods are susceptible to attack only until about half grown, and that rains, to carry the disease spores to the pods, must occur during this period of two or three weeks or else no pod infection takes place.

It was possible to grow abundant supplies of diseased seed for use in these experiments by simply spraying young pods with a suspension of *P. lingam* spores during or immediately after a rain.

The testing of various methods of seed treatment was done both in the greenhouse and in field plats.

The dust disinfectants tested included Semesan, Semesan Jr., Bayer dust, copper carbonate, and many others. The best results were secured with Semesan and Semesan Jr. In a few tests, these preparations gave good black-leg control, while, in others, they gave practically no control. None of the dust treatments can be recommended for use against black-leg.

The liquid chemical treatments included mercuric chloride, Semesan, Uspulun, and Germisan. Germisan used at 0.25 per cent for two hours was very effective against black-leg; but this treatment was also very liable to injure the seed, and so cannot be recommended. Shorter treatments were not effective. Uspulun at 0.25 per cent for two hours was safe, but little, if any, more effective than the standard mercuric chloride. This latter treatment (0.1 per cent mercuric chloride for one-half hour) was not satisfactory except in cases of moderate to light disease attacks. Semesan liquid treatment was much less effective than mercuric chloride. Other chemical treatments varied in their behavior, but none were found that were

[1]A semi-popular report on these experiments appears in Bulletin No. 550 of this Station on "Black-leg Disease of Brussels Sprouts, Cabbage, and Cauliflower," by E. E. Clayton.

at once safe and effective. None of the chemical soaking treatments can be recommended for black-leg.

Hot water treatments at 50°, 55°, and 60°C were tested, and effective black-leg control was secured at all of these temperatures by suitably regulating the length of exposure. Treatments of 25 minutes at 50°, 10 minutes at 55°, and 4½ minutes at 60° were about equally effective.

The 25-minute treatment at 50° C is preferred since the margin of safety is greater and hence less chance of seed injury. No hot water treatment used completely eliminated black-leg infection, even the most effective leaving a trace of disease alive on very heavily diseased stocks which was sufficient to cause appreciable loss in the crop.

While very heavily infected seed can be produced, commercial stocks rarely contain more than a trace of infection to begin with. Three years of field work, during which time commercial stocks were treated for hundreds of growers, showed that the hot water treatment was practically 100 per cent effective under such conditions. In addition, it was found that the treatment often exercised a very favorable influence on subsequent plant growth.

On the basis of these experiments, it is recommended that cabbage and brussels sprouts seed be soaked 25 minutes in water at 50° C as the most satisfactory protection against black-leg infection. It is further recommended that this work be carried out under some system such as the central treating station plan and not by individual farmers at home.

INTRODUCTION

The work here reported was conducted on Long Island during the period of 1922 to 1927, inclusive. At the time the experiments were initiated, growers in this locality were suffering very severe losses from the black-leg disease which affected the brussels sprouts crop most severely but also cabbage, and to a lesser degree, cauliflower. Field surveys indicated that a large part of the infection was seed borne and that the mercuric chloride treatment, which was being used by a few, was not proving effective. Since the experimental work with seed treatments for black-leg was scanty and the results in many instances inconclusive, it seemed desirable to make a thoro survey of the subject and to test out carefully the possibilities of various types of treatment, such as heat, chemical soaking, and dry dusts.

HISTORICAL

BLACK-LEG SEED INFECTION AND SEED TREATMENT

Black-leg is recognized as a disease that is seed borne, and most growers first encounter this disease thru the sowing of infected seeds. Indeed it is probable that the majority of black-leg epidemics trace directly to the use of infected seed, for even in those cases where soil infection is found responsible the infection will usually be traced to disease introduced through seed at some previous time.

Walker (10)[2] states that, "Observations by the writer have strengthened the belief that infected seed is the chief cause of heavy losses from black-leg," and this opinion coincides with the writer's own experiences. Manns (4), who was first to work with this disease in this country, did not think it internally seed borne, for he writes that, "Of the four mentioned diseases (black-rot, black-leg, club-root, and Fusarium wilt) there is no evidence whatever that any one is carried internally in the seed and the possibility of such being the case is far remote."

Henderson (3), however, demonstrated that the disease is seed borne and that the parasite exists not merely on the seed as an external contamination but penetrates the seed coat and reaches the interior. Seed treatment as a control measure for this disease was recommended by Henderson, and soaking in formalin or mercuric chloride solutions was suggested.

Norton (6) in 1919 made brief mention of the use of hot water treatment for black-leg infected seed and considered this method promising.

Walker (10) reported the first thoro work on seed treatment for black-leg, but he was greatly handicapped in the conduct of his experiments by the fact that he was able to secure only limited quantities of diseased seed. As the result of his investigations he concludes that, "At the present hot water treatment does not appear to be sufficiently superior to the mercuric chloride treatment described later to warrant its recommendation for general use. Further comparative trials, however, should be made."

In a later publication, Walker (9) discusses the mercuric chloride treatment for black-leg and states that, "Its only limitation—and this is often a serious one—is that the black-leg fungus tho greatly reduced in amount is not entirely killed."

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[2]Refers to Literature Cited, page 58.

Rex (7), working in Pennsylvania, has reported recently on seed treatment for black-leg. As the results of his experiments, he concludes that two organic mercury disinfectants, Uspulun and Semesan, were superior to mercuric chloride, and he recommends the use of these materials in preference to hot water treatments which he found to be slightly more effective but likely to cause seed injury. It appears that this investigator drew his conclusions in part from laboratory tests in which the disinfectants were compared on the basis of their efficiency in destroying a species of Alternaria and not the black-leg fungus (*Phoma lingam* (Tode) Desm.) and in part from field experiments where his seed treatment results were complicated by the occurrence of heavy soil infection. As would be expected under these conditions, the field plats, treated or otherwise, all showed high percentages of disease. In view of these facts the accuracy of his conclusions is open to question.

Cunningham (1), in the most recent investigation of this disease, reports on experiments with swedes and turnips. He found the fungus to be the same as that causing black-leg of cabbage and other crucifers in this country, tho he very conclusively proved the existence of a number of strains. He found the organism seed borne but reports that mercuric chloride failed to destroy the infection even when carried to the point of serious seed injury. Treatments with Semesan, Uspulun, and Germisan were completely ineffective. Hot water treatments, including 30 minutes at 122° F, also failed to give control. Hot Semesan solutions were completely effective but likely to injure the seed unless it possessed high germination.

INFECTION OF SEED PODS BY BLACK-LEG FUNGUS

Henderson (3) and Walker (10) observed the black-leg lesions on cabbage seed pods. Both of these investigators, however, were greatly hampered in their studies of seed treatment by the fact that they could secure only a very limited supply of infected seed. It appeared essential when initiating these experiments to study the mechanics of seed pod infection, both to discover the reasons for the marked variations in the amount of seed pod infection occurring in different years in the commercial seed fields and to find a way to grow abundant supplies of infected seed. In the cabbage seed growing area of Long Island, seed is sown in the late summer and the young plants, when just beginning to form heads, are trenched for the winter. The weather conditions during the late summer do not favor the development and spread of black-leg, so it is seldom

that the disease makes a conspicuous development during the fall following seed sowing.

In the spring the disease lesions are first observed on the lower leaves of the newly formed seed stalks. These lesions are circular, from 10 to 15 mm in diameter, and they develop mature pycnidia and pycnospores by the time the pods are set. This fact, as well as other considerations, indicates that the pod infections come chiefly from spores produced on the lower leaves of the plant. The pod lesions appear as purplish dots with the color shading out gradually from center to border. These enlarge in size very slowly for the three weeks immediately following infection. Indeed they are so small that the casual observer would overlook them entirely. After this period, however, and especially following a rain, the fungus becomes very active and soon develops circular, purplish, depressed spots from 4 to 5 mm across and from 5 to 15 mm long. As the seed pods approach maturity, the lesions become raised with a purplish border and a white interior thru which the pycnidia are scattered. Rainy weather is essential for the free production of pycnidia on the surface of the pod lesions, and prior to the formation of pycnidia it is impossible in the field to distinguish black-leg pod lesions from the lesions caused by any one of several other organisms, such as *Peronospora parasitica* (Pers.) DeBary or *Bacterium maculicolum* McCulloch, organisms which are both very common causes of pod spots.

The Phoma lesions, however, have a very distinctive appearance following the formation of pycnidia. Beneath the pod lesions the fungus often spreads freely thru the interior of the pod attacked and completely destroy the seed. Often, however, the seed is infected, and afterwards the progress of the infection is checked as the seed ripens and dries. In this way the fungus is carried in viable seed which later serves as a primary source of black-leg in the plant bed.

Field observations showed that the Phoma lesions were always located on the upper surface of the pod as it grew on the plant. Thus, when viewed from above, a plant might show dozens of infections not one of which would be visible if the plant were pulled and observed from below. Quite frequently single pods showed a row of three, four, or half a dozen separate lesions distributed in a straight line from the pedicel to the beak of the pod. Artificial inoculations, however, have proved that the regular arrangement of the lesions

on the upper pod surface is not due to variations in the susceptibility of different parts of the pod; and furthermore it has been noted that the lesions correspond in position with the rows of water droplets which always form in lines on the upper surface of the young seed pods following a rain or heavy dew. After they have weathered with age, the pods no longer hold the water drops in straight rows and consequently the Phoma lesions may be said to correspond with the water drops as located on pods during the early stages of development.

The seed plants blossom and set their pods in June. By early July the pods are half grown and by the last of the month the seed is matured and ready to cut. During 1922 and 1923 the rainfall was scant for the part of June which followed the setting of the pods. In both years, however, there was plenty of rain during the first half of July, and the the writer, confidently expecting abundant seed pod infection, made a careful search of seed fields. Contrary to expectations, the seed crop each of these years was exceptionally free from black-leg.

In 1923 and also in 1924, beginning with the time seed pods were half grown, plants were artificially inoculated by spraying with spore suspensions. These inoculations resulted in very few infections, tho many of the pods showed purplish dots following inoculation which failed, however, to make further development. The season of 1924 revealed the difficulty. That year, June was wet with several heavy rains during the two weeks following pod setting. July was a month of complete drought. Consequently, for the first two weeks (approximately from June 10 to 24), the young pods were exposed to rain, while for the last five weeks (June 25 to August 1) drought prevailed. Nevertheless, the seed crop of 1924 was very heavily black-leg infected, indicating that a moist period in June was sufficient to cause severe infection.

The question of age of pods in relation to pod infection was further investigated the following two years. In 1925 successive lots of seed plants were spray inoculated. The work was begun when the pods were less than one-fourth grown and continued until the last inoculation was made on pods that were practically mature. The inoculations of pods less than one-half grown were highly successful and resulted in numerous infections. Pods that were more than one-half grown showed incipient infections following the inoculations, but the lesions failed to increase in size except in rare instances.

The matter was tested again in 1926. That year a row of cabbage seed plants was sprayed with spores on June 22 at which time the pods were half grown or less in size. The inoculation was carried out between showers of rain. The pods developed the small purplish infection dots within a few days and the lesions increased gradually. On July 12 they appeared as roundish, purple spots without definitely defined borders. On July 13 it rained and the examination on July 14 showed a marked change, for now hundreds of the spots had well-developed pycnidia. Surveys thru the cabbage seed producing section at this time revealed much natural infection in the commercial seed fields, the pycnidia having developed following the rain. Similar results were secured in 1927.

In summary, then, the pods have been found susceptible to infection up to the time they are half grown. Under Long Island conditions, this means that infection takes place before the first of July and that rains during the latter part of June are essential. The formation of pycnidia may occur from about July 10 on to harvest and is also dependent on rain, the moisture seeming to provide a necessary stimulus. Taking advantage of these findings, the writer has been able to produce abundant supplies of heavily infected cabbage and sprouts seed, and these seed stocks have made possible extensive tests of seed treatments.

METHODS OF EXPERIMENTATION

Seed treatment experiments fall naturally into two classes, i. e., laboratory and field tests. Laboratory tests in turn may consist of planting treated and untreated lots of seed in petri dishes of agar. This sort of test is conducted under entirely artificial conditions and the results are often complicated by the presence of other organisms on or in the seed. On the whole, the petri dish method has not proved very satisfactory and it has generally been used when there was but a very limited supply of diseased seed available. The writer has employed the petri dish method in only a few preliminary experiments, and in place of it has developed and used the following method of testing in the greenhouse.

Lots of seed pods were secured that were 100 per cent diseased and the seed shelled out. These stocks naturally had a high percentage of infected seeds. Each season more than sufficient seed for a single year's work was gathered so that in the course of time seed stocks that were one, two, and three years old were available. The

standard sample used was 500 counted seeds, and in these experiments treatments were represented by one or more samples. Each seed lot was sown in a flat of sterilized soil. A method of sowing was followed that insured planting of all seed at a uniform depth, a necessary precaution where comparative germination counts are to be made. Ordinary well water was used for watering, but the work was done with care to avoid needless splashing. In most of the greenhouse experiments one or more flats were sown with healthy seed as a check against possible spread of disease from one flat to another, but in no case was the disease ever found in one of these healthy seed checks.

Under greenhouse conditions when diseased seed is sown, black-leg appears as a damping-off affecting the seedlings. In the early stages this damping-off caused by the black-leg fungus cannot be distinguished from damping-off caused by other fungi. About three weeks after seed sowing, however, pycnidia begin to develop on the stems of the black-leg attacked plants. These pycnidia are black, round, and raised. They are readily seen, and in case of doubt can be observed quickly in a drop of water under the low power of the microscope. Under these conditions the spores are discharged in characteristic ribbon-like columns from the mouths of the pycnidia. The practise in these experiments was to make two counts of black-leg plants at intervals of 10 to 14 days and to remove the plants as counted. In experiments where germination records were made, this was done when the plants were 10 to 14 days old.

It was found that during certain periods the disease made a virulent development in the greenhouse, while at other times it did not. Thus, untreated diseased seed sown in March, April, or May would yield perhaps 10 times as many diseased plants as the same seed sown in December or January. It was further proved that a virulent disease development was essential for a critical comparison of different methods of seed treatment in the greenhouse, or for that matter out of doors. Consequently, the great majority of tests here reported were conducted during the months of March and April.

This greenhouse method of testing made possible the elimination of many inefficient forms of seed treatment and also many others which were efficient but likely to injure the seed. Comparisons of results from the field and greenhouse tests have shown that the results secured in the greenhouse were reliable. This was not assumed, however, and extensive use has been made of field test plats, both small and large.

In the small plat field tests, each treated and untreated lot was separated from all other lots in the plant bed by an interval of 8 to 12 feet. Check lots of healthy seed were planted immediately adjacent to the untreated seed plat, and these healthy seed checks proved whether or not there was any spread of disease between plats. Of the many experiments conducted, however, only one had to be discarded because of disease spreading from one plat to another. The land used had not grown crucifers for many years, and the sowing of healthy seed check plats insured, of course, the speedy detection of any soil infection had it been present.

After the plants in the seedbed were large enough they were transplanted, one lot at a time, into field plats. The transplanting was done by hand, and the workmen usually washed their hands and implements in a disinfecting solution between lots. Tests have indicated, however, that, where reasonable care is taken, this precaution is unnecessary. At the time of transplanting, disease counts were taken if sufficient disease had developed during the plant bed period to make this possible. In most experiments, there was very little evidence of black-leg disease by the time the plants were ready to transplant, even in check plats sown with untreated diseased seed. The main and final disease counts were made late in the fall since plants continue to die thruout the summer.

In addition to small plat field experiments, large scale field tests have been conducted with the hot water treatment, since this treatment is the only one that has consistently given good results. The object of these tests was to prove, first, the effectiveness of this process under field conditions and, second, to discover the best practical method of using the treatment. A hot water treating plant was established at the Vegetable Research Farm at Riverhead, and during the springs of 1925, 1926, and 1927 seed stocks brought in by growers were tested for germination and ability to stand the treatment and, if the test was satisfactory, were processed and taken away by the growers to dry and plant. About 1,500 pounds of cabbage, cauliflower, and brussels sprouts seed which went out to scores of growers were treated in this way each of the last two years.

Considering the situation as a whole, the writer feels that the laboratory test, the small field plat test, and the general field test are all necessary and supplementary in seed treatment experimentation.

RESULTS FROM GREENHOUSE EXPERIMENTS

HOT WATER TREATMENTS AT 50°C

The hot water treatment recommended as best by Walker (10) was 30 minutes at 50° (122°F). As he pointed out, however, his results were too few for him to be certain that this was the best exposure, and consequently the effects of various exposures at 50° on disease control and also on seed germination have been investigated. The experiment reported in Table 1 was conducted with the usual 500-seed lots of a very severely diseased cabbage seed stock.

TABLE 1.—COMPARISON OF TREATMENTS OF CABBAGE SEED WITH WATER AT 50° C FOR 5 TO 40 MINUTES.

LENGTH OF TREATMENT IN MINUTES	SERIES A			SERIES B			TOTALS
	Number of black-leg plants after			Number of black-leg plants after			
	21 days	28 days	36 days	21 days	28 days	36 days	
Untreated	51	124	62	20	72	41	370
Untreated	48	117	71	31	74	47	388
5	12	49	44	6	19	30	160
8	7	16	17	0	3	2	45
10	2	16	4	1	4	2	29
13	0	12	15	0	3	1	31
15	0	3	0	0	0	0	3
18	0	1	0	0	0	0	1
20	0	0	1	0	0	0	1
25	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0
40	0	0	0	0	1	0	1

The effectiveness of the shortest hot water treatments as indicated by these results was astonishing. Even a five-minute treatment materially reduced the amount of disease. Furthermore, with each increase in the length of treatment there was a reduction in the amount of disease until the exposure reached 18 minutes. Control from here on to 40 minutes was almost perfect. It is important to note that there was distinctly more disease in Series A than in Series B, which was due to a slightly different location in the greenhouse. The more severe the disease development, the more critical the test, as shown in Series B where 15 minutes was 100 per cent effective, while in Series A 100 per cent control was not attained until the exposure reached 20 minutes. None of the treatments from 5 to 35 minutes perceptibly reduced germination.

The results of this experiment indicated that with a temperature of 50° the treatments were distinctly more effective as the exposure was increased up to about 20 minutes. Increasing the exposure from 20 to 25 and from 30 to 35 minutes, however, showed no corresponding gain in efficiency.

The next experiment was designed to test thoroly the relative value of exposures from 20 to 30 minutes. In this experiment, each treatment was represented by five lots of 500 seeds each. The results are given in Table 2.

TABLE 2.—COMPARISON OF TREATMENTS OF CABBAGE SEED WITH WATER AT 50°C FOR 20 TO 30 MINUTES.

LENGTH OF TREATMENT IN MINUTES	NUMBER OF BLACK-LEG INFECTED PLANTS					TOTAL
	Flat 1	Flat 2	Flat 3	Flat 4	Flat 5	
Untreated	158	183	190	170	184	885
20	2	4	12	1	2	21
22	5	2	2	2	4	15
25	0	0	1	0	0	1
30	0	2	1	0	0	3

Increasing the time of exposure from 20 to 22 minutes and from 22 to 25 minutes gave, in each case, distinctly better disease control. Increasing the exposure from 25 to 30 minutes, however, resulted in no gain, tho there was still a trace of infection. In the previous experiment it was established that even as much as 40 minutes at 50° will not completely destroy all black-leg infection. The conditions for disease development in this experiment were good, as indicated by the high counts in the check, and consequently the treatments were put to a severe test. As will be noted later, under less favorable conditions for disease development, the difference in effectiveness between a 20- and a 25-minute treatment may not be apparent.

On the basis of the two experiments it was concluded that, with temperature at 50°, exposures of 18 minutes or more will destroy most of the infection and that there is no object in treating seed longer than 25 minutes. Later results confirmed this conclusion.

Not uncommonly, in using the hot water form of treatment, difficulty is experienced in maintaining the temperature at just the right point. It seemed desirable to determine the effect upon both disease control and germination of temperatures just above and just below 50°.

TABLE 3.—EFFECT ON DISEASE CONTROL AND GERMINATION OF CABBAGE SEED OF TREATMENT AT TEMPERATURES SLIGHTLY HIGHER OR SLIGHTLY LOWER THAN 50°C.

LENGTH OF TREATMENT IN MINUTES	DEGREES C	TOTAL NUMBER OF PLANTS	NUMBER OF BLACK-LEG INFECTED PLANTS		
			21 days	29 days	Total
25	53	262	5	4	9
25	51½	281	5	0	5
25	50	332	8	5	13
25	48½	367	5	10	15
25	47	335	13	14	27
Check		286	21	15	36

The results of this test (Table 3) were not very definite. It appears, however, that the efficiency of the treatment in disease control diminished rapidly as the temperature dropped below 50°. The optimum for disease control in this experiment was 51.5° and for germination 48.5°. It is interesting to note that the one is 1.5 degrees above 50° and the other the same amount below.

This experiment was repeated (Table 4), but again conditions did not favor a virulent disease development.

TABLE 4.—EFFECT ON DISEASE CONTROL AND GERMINATION OF CABBAGE SEED OF TREATMENT AT TEMPERATURES SLIGHTLY HIGHER OR SLIGHTLY LOWER THAN 50°C.

LENGTH OF TREATMENT IN MINUTES	DEGREES C	TOTAL NUMBER OF PLANTS	NUMBER OF BLACK-LEG INFECTED PLANTS		
			22 days	35 days	Total
25	48	687	7	3	10
25	49	758	0	3	3
25	50	668	2	1	3
25	51	601	2	2	4
25	52	638*	0	1	1
Check		774	74	46	120

*Plants much stunted and weakened.

The data show that with respect to disease control there is little difference between 49°, 50°, and 51°, but that there was a marked increase in disease with a drop to 48° and a similar decrease with a rise to 52°. None of the exposures seriously reduced germination as indicated by the test, but the 52° lot produced weakened and stunted plants.

HOT WATER TREATMENTS AT 55° AND 60° C

In the previous experiments a temperature of 50° was used. It seemed reasonable to suppose that, by properly adjusting the time,

temperatures 5 or 10 degrees higher could be employed. To test this, one- and two-year-old diseased seed in 500-seed lots were treated from 8 to 20 minutes with uniform temperature of 55°. The treatments up to and including 12 minutes did not appreciably reduce germination. Fifteen minutes at this temperature reduced germination one-third, and 20 minutes reduced it two-thirds. However, insufficient black-leg developed to make possible a count either in treated or untreated check flats. On the basis of the germination, it appeared that 10 to 12 minutes at 55° was about equal to 25 or 30 minutes at 50°.

The tests at 55° were repeated, using one- and two-year-old diseased seed stocks (seed lots No. 205 and No. 261). The results of this experiment are given in Table 5.

TABLE 5.—EFFECT ON DISEASE CONTROL AND GERMINATION OF CABBAGE SEED OF EXPOSURES FOR 5 TO 15 MINUTES AT 55° C.

LENGTH OF TREATMENT IN MINUTES	DEGREES C	GERMINATION COUNTS AFTER 12 DAYS		TOTAL GERMINATION	TOTAL BLACK-LEG PLANTS
		Seed lot No. 205	See lot No. 261		
Check		262	326	588	13
20	50	178	288	466	2
25	50	215	294	509	0
5	55	217	260	477	0
7	55	248	303	551	0
9	55	182	261	443	1
10	55	187	298	485	0
11	55	118	338	456	0
12	55	166	245	411	0
13	55	246	310	556	0
15	55	149*	325*	474*	0

*Stunted and weak-growing plants.

Again there was not sufficient disease to make this a critical test, for only 13 black-leg plants appeared in the untreated check. The germination results indicated that exposures longer than 13 minutes were very injurious to the seed.

In a similar manner, tests were conducted using a temperature of 60°C. In the first of these, one- and two-year-old diseased seed (Lots 205 and 203) were treated, and the results are given in Table 6.

Consideration of the results, both with respect to germination and disease counts, makes it apparent that an exposure of 4 or 4½ minutes at 60°C was about equal to 25 to 30 minutes at 50°C. Conditions did not favor a virulent disease development, and hence

TABLE 6.—EFFECT OF CHEMICAL TREATMENTS AND OF HOT WATER TREATMENTS OF 3 TO 7 MINUTES AT 60° C ON GERMINATION AND DISEASE OF CABBAGE SEED.

LENGTH OF TREATMENT IN MINUTES	DEGREES C	GERMINATION COUNTS AFTER 13 DAYS	NUMBER OF INFECTED BLACK-LEG PLANTS AFTER 21 DAYS
	Seed Lot No. 205		
Hot water: 3	60	327	0
4	60	342	0
5	60	299	0
5	60	308	0
6	60	309	0
7	60	238	0
25	50	367	0
Uspulun:			
0.5 per cent, 120	20	354	11
Germisan:			
0.25 per cent, 120	20	372	1
Check	——	298	14
Check	——	350	21
	Seed Lot No. 303		
Hot Water: 3	60	168	0
4	60	167	1
5	60	85	0
6	60	98	0
7	60	43	0
25	50	129	0
Uspulun:			
0.5 per cent, 120	20	147	4
Germisan:			
0.25 per cent, 120	20	87	0
Check	——	118	15

there is little difference in the results secured from the various heat treatments. For comparison, two chemical soaking treatments were included.

COMPARISONS OF HEAT TREATMENTS AT 50°, 55°, AND 60°C

It seemed desirable now to compare treatments at 50°, 55°, and 60° and to determine whether there was any special advantage in using one or another of these temperatures. In the first of these comparison experiments, two lots of one-year-old seed (No. 302 and No. 303) and one lot of two-year-old seed (No. 205) were used. The seed lots were heavily black-leg diseased, of course, and the customary 500-seed samples were employed.

The effect of treatments on germination is almost as important as the effect on disease, and any treatment is unsatisfactory if it causes (a) serious reduction in the percentage of germination, (b) delayed

germination, or (c) weak-growing seedlings. Some harmful seed treatments do not reduce the percentage of germination at once but cause delayed germination and reduced vigor. Experience has shown that anything that reduces the ability of the seed to get above ground quickly and grow vigorously will ultimately shorten the life of the seed and increase the liability of a poor stand when this seed is sown in the field.

To measure the effects of the treatments on the rapidity of germination as well as on the ultimate percentage of germination, the counts (Table 7) in this experiment were taken after 7 and 15 days.

TABLE 7.—EFFECT ON GERMINATION OF CABBAGE SEED OF CHEMICAL TREATMENTS AND OF HOT WATER TREATMENTS AT 50°, 55°, AND 60°C.

LENGTH OF TREATMENT IN MINUTES	DEGREES C	GERMINATION COUNTS, LOT No. 205		GERMINATION COUNTS, LOT No. 302		GERMINATION COUNTS, LOT No. 303	
		7 days	15 days	7 days	15 days	7 days	15 days
Hot water:							
25	50	319	312	264	246	154	171
25	50	309	318	226	245	156	174
13	55	241	318	169	177	79	129
13	55	269	288	140	195	113	171
4½	60	226	287	220	218	132	180
4½	60	310	330	192	218	125	163
Germisan: 0.4 per cent, 60	20	101	259	101	149	49	113
Check	—	383	359	189	179	136	133

LENGTH OF TREATMENT IN MINUTES	DEGREES C	AVERAGE GERMINATION PER FLAT	
		7 days	15 days
Hot water:			
25	50	239.6	
13	55	168.5	245.0
4½	60	200.8	213.0
Germisan:			232.6
0.4 per cent, 60	20	83.7	173.4
Check	—	230.0	236.0

Realizing that seed injury is evidenced both by reduction in actual percentage of germination and also by the time required for plants to appear, inspection of the above figures shows that the 25-minute treatment at 50° caused no injury, 4½ minutes at 60° caused slight injury, 13 minutes at 55° caused more pronounced injury, while 60 minutes soaking in 0.4 per cent Germisan was the most harmful treatment of all.

Disease counts were made on April 7 and April 15 with the results shown in Table 8.

TABLE 8.—EFFECT ON DISEASE IN CABBAGE SEED OF CHEMICAL TREATMENTS AND OF HOT WATER AT 50°, 55°, AND 60° C.

LENGTH OF TREATMENT IN MINUTES	DEGREES C	NUMBER BLACK-LEG PLANTS LOT NO. 205		NUMBER BLACK-LEG PLANTS LOT NO. 302		NUMBER BLACK-LEG PLANTS LOT NO. 303		TOTAL
		21 days	28 days	21 days	28 days	21 days	28 days	
Hot water:								
25	50	2	3	5	3	0	0	13
25	50	0	0	5	0	2	2	9
13	55	1	1	0	0	0	0	2
13	55	0	0	0	0	0	0	0
4½	60	0	0	1	2	0	0	3
4½	60	0	0	5	6	0	1	12
Germisan:								
0.4 per cent,								
60	20	0	0	1	0	2	1	4
Check	—	21	15	5	4	16	6	67

LENGTH OF TREATMENT IN MINUTES	DEGREES C	AVERAGE OF BLACK-LEG COUNTS
Hot water:		
25	50	3.7
13	55	0.33
4½	60	2.5
Germisan:		
0.4 per cent,		
60	20	1.3
Check	—	22.33

The disease counts indicate that of the three heat treatments used 13 minutes at 55° was the most effective, 4½ minutes at 60° next, and 25 minutes at 50° least effective. Germisan at the strength used was highly effective but very injurious to the seed.

This experiment showed that after a certain point is reached increased efficiency in disease control is secured only at the cost of severe seed injury, and consequently there is a limit to the degree of effectiveness that is desirable.

On the basis of these experiments an attempt was made to set empirically a maximum safe exposure for the different temperatures, *viz.*, 50°, 55°, and 60° C, and also for an exposure slightly in excess of what was judged safe. The effect of these six treatments on germination and disease control in cabbage seed was determined, and the data are given in Tables 9 and 10. The shorter time in each case represents the so-called safe exposure. Thus, 4 minutes compared with 5 minutes for 60°; 10 minutes with 13 minutes for 55°; and 25

TABLE 9.—EFFECT ON GERMINATION OF CABBAGE SEED OF HOT WATER TREATMENT AT 50°, 55°, AND 60° C.

LENGTH OF TREATMENT IN MINUTES	DEGREES C	GERMINATION COUNTS AFTER 10 DAYS, LOT. NO. 302, FLATS 1 AND 2	GERMINATION COUNTS AFTER 10 DAYS, LOT NO. 205, FLATS 1 AND 2	AVERAGE GERMINATION PER FLAT
4	60	645	647	323.00
5	60	565	621	295.50
10	55	610	532	285.50
13	55	543	536	269.75
25	50	607	596	300.75
33	50	508	553	265.25
Check	—	540	633	293.25

TABLE 10.—EFFECT ON DISEASE IN CABBAGE SEED OF HOT WATER TREATMENTS AT 50°, 55°, AND 60° C.

LENGTH OF TREATMENT IN MINUTES	DEGREES C	NUMBER OF BLACK-LEG PLANTS AFTER 26 DAYS, LOT NO. 303	NUMBER OF BLACK-LEG PLANTS AFTER 26 DAYS, LOT No. 302	NUMBER OF BLACK-LEG PLANTS AFTER 26 DAYS, LOT No. 205	TOTAL
4	60	2	0	0	2
5	60	4	0	0	4
10	55	0	0	6	6
13	55	0	0	0	0
25	50	0	0	0	0
33	50	0	0	1	1
Check	—	303	55	115	473

minutes with 33 minutes for 50°. The germination counts were made 10 days and the disease counts 26 days after seed sowing.

As evidenced by the high count (473) of diseased plants in the check plats, conditions were favorable for disease development, and hence the treatments were put to a severe test. The results as to disease control indicate that any of the six treatments compared would give satisfactory control of the disease under field conditions. Comparing more strictly, however, it appears that 25 minutes at 50° and 13 minutes at 55° each showed no infection, 33 minutes at 50° and 10 minutes at 55° each showed infection in but one flat of the six, and 4 and 5 minutes at 60° in two flats of the six. Since a single infection is liable to escape any heat treatments that can be used with reasonable safety, it appears that in this test the four treatments at 55° and 50° gave about equally good disease control; and of these the two shorter treatments, *viz.*, 10 and 25 minutes, did not reduce germination of the seed stocks used in the test.

VALUE OF REPEATED HEAT TREATMENTS

On the basis of reports from previous work it was thought that the hot water form of treatment would destroy all the black-leg infection present. The experiments to this point, however, have shown that this is not the case and that heat treatments merely reduced the amount of infection to a very low minimum. These same results have been secured with temperatures of 50°, 55°, and 60° C. Since it has not been possible to eliminate completely all disease by any single heat treatment, it was thought desirable before concluding these tests to determine the effect of repeated heat treatments. Two lots of infected seed were used. The seed was treated and afterwards dried until it reached a constant weight and then the process repeated. Untreated checks and checks given the standard mercuric chloride treatment were included. The results are given in Table 11.

The results of this experiment were disappointing in so far as data on disease control were concerned. Conditions did not favor a virulent development of disease, as the relatively low counts in the checks indicate, and all the heat treatments were practically 100 per cent effective. The indications are, however, that if it is desirable to secure seed more free from black-leg infection than the standard single hot water treatment would give, repeating the treatment after the seed has dried will further reduce the amount of infection.

TABLE 11.—EFFECT OF REPEATED TREATMENTS ON GERMINATION AND DISEASE CONTROL IN CABBAGE SEED.

TREATMENT	GERMINATION COUNT AFTER 19 days	BLACK-LEG COUNTS AFTER		TOTAL BLACK-LEG PLANTS
		31 days	41 days	
	Seed Lot No. 303			
Checks	80	11	0	11
Checks	80	5	4	9
Checks	79	7	6	13
Checks	69	10	8	18
Checks, average	76.5	—	—	—
Mercuric chloride*	81	1	1	2
Mercuric chloride	85	2	6	8
Mercuric chloride, average	83	—	—	—
Hot water, 1st treatment	120	0	0	0
Hot water, 1st treatment	101	1	1	2
Hot water, 1st treatment	91	0	1	1
Hot water, 1st treatment	89	0	0	0
Hot water, average	100.3	—	—	—
Hot water, 2nd treatment	96	0	0	0
Hot water, 2nd treatment	93	0	0	0
Hot water, 2nd treatment	98	0	0	0
Hot water, 2nd treatment	93	0	0	0
Hot water, 2nd treatment	81	0	1	1
Hot water, 2nd treatment	83	0	0	0
Hot water, average	90.7	—	—	—
Hot water, 3rd treatment	79	0	0	0
Hot water, 3rd treatment	73	0	0	0
Hot water, 3rd treatment	68	1	0	1
Hot water, 3rd treatment	71	0	0	0
Hot water, 3rd treatment	76	0	0	0
Hot water, 3rd treatment	70	0	0	0
Hot water, average	72.8	—	—	—
	Seed Lot No. 205			
Checks	396	10	14	24
Checks	350	17	31	48
Checks, average	373	—	—	—
Hot water, 1st treatment	357	0	0	0
Hot water, 1st treatment	366	0	0	0
Hot water, average	361.5	—	—	—
Hot water, 2nd treatment	326	0	0	0
Hot water, 2nd treatment	347	0	0	0
Hot water, 2nd treatemnt	299	0	0	0
Hot water, 2nd treatment	327	0	0	0
Hot water, average	324.7	—	—	—
Hot water, 3rd treatment	304	0	0	0
Hot water, 3rd treatment	306	0	0	0
Hot water, 3rd treatment	287	0	0	0
Hot water, 3rd treatment	265	0	0	0
Hot water, average	290.5	—	—	—

*0.1 per cent for 30 minutes.

TABLE 12.—EFFECT ON GERMINATION AND DISEASE IN CABBAGE SEED OF CHEMICAL SOAKING SEED TREATMENTS.

TREATMENTS	GERMINATION COUNTS AFTER 16 DAYS	NUMBER OF BLACK-LEG PLANTS AFTER 37 DAYS
Check	282	37
Check	301	19
Check	265	13
Check	271	12
Check, average	279.81	20.25
Zinc chloride, 1.5 per cent	236	28
Zinc chloride, 0.3 per cent	288	34
Zinc chloride, 0.06 per cent	246	33
Zinc sulfate, 1.5 per cent	249	16
Zinc sulfate, 0.3 per cent	265	14
Zinc sulfate, 0.06 per cent	249	17
Zinc iodide, 1.5 per cent	265	14
Zinc iodide, 0.3 per cent	259	23
Zinc iodide, 0.06 per cent	296	35
Lead acetate, 1.5 per cent	238	10
Lead acetate, 0.3 per cent	213	28
Lead acetate, 0.06 per cent	274	23
Lead nitrate, 1.5 per cent	219	24
Lead nitrate, 0.3 per cent	294	10
Lead nitrate, 0.06 per cent	278	15
Nickel sulfate, 1.5 per cent	112	0
Nickel sulfate, 0.3 per cent	245	4
Nickel sulfate, 0.06 per cent	275	10
Potassium arsenate, 1.5 per cent	28	0
Potassium arsenate, 0.3 per cent	92	0
Potassium arsenate, 0.06 per cent	221	4
Sodium fluoride, 1.5 per cent	40	0
Sodium fluoride, 0.3 per cent	163	4
Sodium fluoride, 0.06 per cent	242	12
Aluminum sulfate, 1.5 per cent	294	5
Aluminum sulfate, 0.3 per cent	299	6
Aluminum sulfate, 0.06 per cent	295	15
Formaldehyde, 1.5 per cent	57	0
Formaldehyde, 0.3 per cent	209	5
Formaldehyde, 0.06 per cent	282	7
Uspulun, 1.5 per cent	157	1
Uspulun, 0.3 per cent	347	6
Uspulun, 0.06 per cent	312	13
Copper sulfate, 1.5 per cent	159	5
Copper sulfate, 0.3 per cent	260	19
Copper sulfate, 0.06 per cent	274	28
Mercuric chloride, 0.2 per cent	160	1
Mercuric chloride, 0.04 per cent	288	10
Mercuric chloride, 0.008 per cent	351	17
Silver nitrate, 0.2 per cent	41	2
Silver nitrate, 0.04 per cent	159	5
Silver nitrate, 0.008 per cent	265	12

With respect to germination, seed treated twice did not come up as well as seed treated once, and seed treated three times germinated poorest of all. Thus, each repetition of the heat treatment reduces the germination and hence the strength of the seed.

EXPERIMENTS WITH CHEMICAL SEED TREATMENTS

In all the experiments so far reported the primary objective was the determination of the most effective form of hot water seed treatment. Treatments with chemicals were included merely as checks. In the first experiment conducted purely with chemical treatments, a number of different materials were tested, including Uspulun as a representative of the important organic mercury class. Infected red cabbage seed was used and the customary 500-seed samples were treated. The various chemicals were used in three concentrations with a uniform one-hour soaking. By using a wide spread of concentrations it was hoped to secure general information as to ranges either toxic to the seed or of fungicidal value. The temperature of the treating solution was 20° to 21° C. The results are given in Table 12.

Considering the results from the untreated checks, it appears that the disease counts of less than 10 indicate that the solution had fungicidal value, while germination counts of less than 260 indicate a toxic effect upon seed. The three zinc salts and the two lead salts possessed no fungicidal value, and the solutions were either nontoxic or very slightly toxic toward the seed. All the other compounds showed fungicidal value, and all were toxic in the strongest concentration. Considering both factors, none appeared to be superior to Uspulun and mercuric chloride, and of these two the former showed most promise.

In continuing the work along this line, various strengths of Uspulun from 0.2 per cent to 1.0 per cent with intervals of 0.1 per cent were tested. Without giving the data in detail, it was found that some disease escaped even when seed was soaked in 1.0 per cent Uspulun for two hours, and also that strengths in excess of 0.5 per cent with a two-hour exposure tended to reduce germination.

Further tests were made comparing a number of mercury disinfectants with a number of heat treatments. The results of one of these tests are given in Table 13.

All of the heat treatments gave 100 per cent control, making it impossible to compare the effectiveness of the different combi-

TABLE 13.—EFFECT ON DISEASE IN CABBAGE SEED OF HEAT AND CHEMICAL SEED TREATMENTS.

TREATMENTS	NUMBER OF BLACK-LEG PLANTS
Metaphen, 0.1 per cent, 30 minutes soaking	5
Metaphen, 0.1 per cent, 1 hour soaking	5
Metaphen, 0.1 per cent, 2 hours soaking	1
Germisan, 0.25 per cent, 30 minutes soaking	17
Germisan, 0.25 per cent, 1 hour soaking	15
Germisan, 0.25 per cent, 2 hours soaking	4
Germisan, 0.5 per cent, 15 minutes soaking	10
Germisan, 0.5 per cent, 30 minutes soaking	7
Germisan, 0.5 per cent, 30 minutes soaking	7
Germisan, 0.5 per cent, 1 hour soaking	13
Semesan, 0.25 per cent, 1 hour soaking	22
Semesan, 0.5 per cent, 1 hour soaking	13
Uspulun, 0.25 per cent, 1 hour soaking	10
Uspulun, 0.5 per cent, 1 hour soaking	5
Mercuric chloride, 0.1 per cent, 30 minutes soaking	8
Hot water, 14 minutes at 50°C	0
Hot water, 17 minutes at 50°C	0
Hot water, 20 minutes at 50°C	0
Hot water, 25 minutes at 50°C	0
Hot water, 25 minutes at 50°C	0
Hot water, 30 minutes at 50°C	0
Hot water, 14 minutes at 50°C, followed by Germisan 0.25 per cent, 30 minutes soaking	0
Hot water, 14 minutes at 50°C, same as above	0
Hot water, 14 minutes at 50°C, followed by Semesan dust	0
Hot water, 14 minutes at 50°C, same as above	0
Hot water, 17 minutes at 50°C, followed by Semesan dust	0
Checks	17
Checks	21
Checks	25
Checks	14
Semesan Jr. dust	3
Semesan Jr. dust	0

nations of heat and chemical treatment. The chemical soaking treatments gave varying degrees of control, the best results being secured with Metaphen and Germisan. The old mercuric chloride treatment, however, gave almost as good results. None of the treatments reduced germination perceptibly.

Testing out further the comparative value of different organic mercury disinfectants, both with respect to seed toxicity and fungi-

cidal efficiency, the usual 500-seed samples of diseased cabbage were treated, using solutions of Germisan, Uspulun, Metaphen, and mercuric chloride, the four compounds that gave the best results in preliminary experiments. These in turn were compared with 25- and 30-minute heat treatments. The results are given in Table 14.

TABLE 14.—EFFECT ON GERMINATION AND DISEASE IN CABBAGE SEED OF CHEMICAL AND HEAT TREATMENTS.

TREATMENTS	GERMINATION COUNTS AFTER 12 DAYS	NUMBER OF BLACK-LEG INFECTED PLANTS		TOTALS
		23 days	37 days	
Germisan, 0.3 per cent, 2 hours	176	0	0	0
	159	0	0	0
Average	167.5	0	0	0
Uspulun, 0.5 per cent, 2 hours	200	4	9	13
	197	2	13	15
Average	198.5			14
Metaphen, 0.1 per cent, 2 hours	199	9	16	25
	239	1	13	14
Average	219			19.5
Mercuric chloride, 0.1 per cent, 30 minutes	176	1	18	19
	180	2	14	16
Average	178			17.5
Hot water, 50°C, 25 minutes	209	0	0	0
	203	0	0	0
	224	0	1	1
	197	1	0	1
Average	208.3			0.5
Hot water, 50°C, 30 minutes	202	0	0	0
	208	0	1	1
	212	0	0	0
	191	0	1	1
Average	203.3			0.5
Diseased seed check	190	5	19	24
	194	10	30	40
Average	192			32

In making chemical treatments the question of temperature of the solution is encountered, and most chemical treatments for convenience sake are conducted at normal water temperature, i. e. 15° to 22° C. All of the experiments here reported were conducted at temperatures of 19° to 21° C. Increasing the temperature of the treating solution, of course, reduces the time required, a principle that has had

practical application in the hot formaldehyde treatment for potatoes. The question of using hot solutions of chemicals in place of simply hot water has been tried out at various times during the course of these experiments. In general, the results obtained with hot chemical solutions have not been satisfactory. Table 15 gives the results of such a test.

TABLE 15.—EFFECT ON GERMINATION AND DISEASE IN CABBAGE SEED OF HOT CHEMICAL TREATMENT AND HOT WATER AND CHEMICAL TREATMENT AT ORDINARY TEMPERATURES.

PLAT No.	TREATMENTS	GERMINATION COUNTS	NUMBER OF BLACK-LEG INFECTED PLANTS		TOTAL
			March 21	April 10	
1	Checks	393	123	72	195
2		359	161	84	245
3		357	122	69	191
	Average	369.7			210.3
1	Hot water, 50°C, 20 minutes	415	1	3	4
2		422	3	25	28
3		389	0	0	0
	Average	408.7			10.7
1	Semesan, 0.5 per cent, 1 hour	431	5	48	53
1	Uspulun, 0.4 per cent, 1 hour	380	3	20	23
1	Germisan, 0.4 per cent, 1 hour	322	2	11	13
	Average	378.7			29.7
1	Germisan, 0.4 per cent, 15 minutes 50°C	337	1	28	29
2		408	4	14	18
3		362	1	4	5
4		337	0	1	1
	Average	361			13.3
1	Uspulun, 0.4 per cent, 15 minutes 50°C	407	0	2	2
2		360	28	103	131
3		342	18	66	84
4		397	2	56	58
	Average	376.5			68.8
1	Semesan, 0.4 per cent, 15 minutes 50°C	355	18	37	55
2		379	4	71	75
3		390	4	23	27
4		427	7	19	26
	Average	387.7			45.7

The hot water and hot Germisan treatments were highly effective, but the Germisan treatment injured the seed severely while the heat

treatments did not. Treatments with hot Uspulun and Semesan were distinctly less effective.

DUST SEED TREATMENTS.

In a previous experiment, Semesan Jr. dust was used and the results in this case were excellent. Other tests with this and other dusts have not given such good results. Thus an experiment was made comparing dust preparations from several sources. The results are given in Table 16.

TABLE 16.—COMPARISON OF DUST SEED TREATMENTS FOR BLACK-LEG IN CABBAGE SEED.

TREATMENTS	BLACK-LEG INFECTED PLANTS		
	Flat 1	Flat 2	Total
Semesan	10	27	37
Semesan Jr.	16	37	53
Tutan	27	33	60
Corona (copper carbonate)	43	64	107
Bayer 140	31	36	67
Segetan	28	40	68
Check	82	141	223

The figures in Table 16 show that Semesan dust was the most effective, but that none of the dusts gave satisfactory disease control.

In the final greenhouse test the best dust treatment, the best chemical soaking treatment, and the best hot water treatment were compared for their effect on germination and disease control. These data are given in Tables 17 and 18.

TABLE 17.—COMPARISON OF THE BEST DUST, CHEMICAL SOAKING, AND HEAT TREATMENTS FOR THEIR EFFECT ON GERMINATION OF CABBAGE SEED.

TREATMENTS	GERMINATION COUNTS				
	Seed lot No. 205		Seed lot No. 301		Average of
	Flat 1	Flat 2	Flat 1	Flat 2	both lots
Semesan dust	294	235	287	236	263.0
Germisan, 0.25 per cent, 1 hour	196	279	243	215	233.3
Germisan, 0.25 per cent, 2 hours	225	195	245	236	225.3
Hot water, 25 minutes, 50°C	252	177	201	205	208.8
Check	307	227	161	242	234.3

TABLE 18.—COMPARISON OF THE BEST DUST, CHEMICAL SOAKING, AND HEAT TREATMENTS FOR THEIR EFFECT ON DISEASE IN CABBAGE SEED.

TREATMENTS	BLACK-LEG INFECTED PLANTS				
	Seed lot No. 205		Seed lot No. 301		Total for both lots
	Flat 1	Flat 2	Flat 1	Flat 2	
Semesan dust	3	10	7	4	24
Germisan, 0.25 per cent, 1 hour	4	0	2	1	7
Germisan, 0.25 per cent, 2 hours	0	0	0	4	4
Hot water, 25 minutes, 50°C	0	0	0	0	0
Check	4	6	7	6	23

Inspection of the table will show that the dusted seed germinated best, better even than the untreated check, but the disease counts show that dusts were entirely ineffective in controlling black-leg. The Germisan treatments greatly reduced the amount of disease, while the hot water treatment gave complete control. Neither gave as good germination as the untreated check, tho the difference was not great.

RESULTS FROM FIELD EXPERIMENTS

At the time the field tests were begun only a limited body of results from the greenhouse tests was available, and furthermore, it was uncertain just how much dependence could be placed on these results. Consequently, in the first years of field test work a variety of treatments was compared. Uspulun and Semesan, organic mercury preparations, and mercuric chloride and mercuric iodide, inorganic mercury compounds, were used as chemical soaking treatments; while Semesan Jr. was used as a dust, and several hot water treatments were included. The seed stocks used were cabbage known to carry infection and ranging in age from one month to three years. The seed was treated May 15 and sown two weeks later in separate seedbed plats. Later, plants were taken from each seedbed plat and set out in field plats. The black-leg disease this year appeared during the latter part of the seedbed period in the form of both stem and leaf lesions. All the plants in each plat were pulled and the diseased ones tabulated and discarded. These counts are given in Table 19.

The seedbed counts show the least disease in the plats sown with hot water treated seed and the most in the plats sown with liquid

TABLE 19.—EFFECT OF SEED TREATMENT ON BLACK-LEG IN THE CABBAGE SEEDBED IN 1924.

TREATMENTS	NUMBER OF LEAF LESIONS ON SEED LOTS				NUMBER OF STEM LESIONS ON SEED LOTS				TOTAL OF ALL LOTS	AVERAGE OF ALL LOTS
	1	2	3	4	1	2	3	4		
Check	8	11	15	9	1	5	33	6	88	11
	7	7	18	19	3	15	16	20	105	13
Mercuric chloride, 0.1 per cent, 0.5 hour	0	5	5	8	0	0	4	3	25	3
Semesan, 0.25 per cent, 1 hour	—	6	27	2	—	1	25	0	61	10
0.25 per cent, 2 hours	1	9	7	4	1	0	39	3	64	8
0.25 per cent, 4 hours	10	4	7	5	3	1	17	9	56	7
Uspulun	—	5	—	—	—	1	—	—	6	3
Mercuric iodide, 0.05 per cent and potassium iodide, 0.1 per cent, 1 hour	—	5	—	—	—	0	—	—	5	2
2 hours	—	10	5	17	—	2	5	4	43	7
4 hours	—	2	2	13	—	2	3	.5	27	4
Semesan Jr. dust	2	2	4	0	0	0	4	0	12	1
Hot water, 14 minutes, 50°C	—	2	0	—	—	0	1	—	3	1
16 minutes, 50°C	0	0	—	0	0	0	—	0	0	0
18 minutes, 50°C	—	4	—	—	—	1	—	—	5	2
20 minutes, 50°C	0	1	—	—	0	0	—	—	1	0
25 minutes, 50°C	0	—	—	0	0	—	3	0	3	1
30 minutes, 50°C	—	—	—	—	0	—	—	—	0	0

TABLE 20.—EFFECT OF CABBAGE SEED TREATMENT ON DEVELOPMENT OF BLACK-LEG IN FIELD IN 1924.

TREATMENT	NUMBER OF PLANTS SET	NET STAND, DEDUCTING LOSS FROM CUT WORMS	HEALTHY PLANTS						PERCENTAGE INCREASE OF HEALTHY PLANTS
			August 21		October 1		November 1		
			Number	Per cent	Number	Per cent	Number	Per cent	
Three-year-old Seed									
Check	167	163	125	76.7	89	54.6	59	36.2	0
Mercuric chloride	70	69	64	92.7	59	85.5	36	52.2	44.2
Semesan, 2 hours	78	69	67	97.1	60	86.9	42	60.9	68.2
Semesan, 4 hours	80	73	67	91.8	62	84.9	30	41.1	13.5
Semesan Jr. dust	71	63	58	92.1	54	85.6	36	57.1	57.7
Hot water:									
16 minutes, 50°C	82	77	69	89.6	67	87.0	59	76.6	111.6
20 minutes, 50°C	88	86	84	97.7	78	90.7	53	61.6	70.2
25 minutes, 50°C	52	50	50	100.0	49	98.0	38	76.0	109.9
Two-year-old Seed									
Check	95	90	75	83.3	55	61.1	31	34.4	0
Check	175	167	110	65.8	81	48.5	36	21.6	0
Average								23.0	
Mercuric chloride	81	78	78	100.0	59	75.6	50	64.1	178.7
Semesan, 1 hour	100	95	66	69.5	53	55.8	41	43.2	87.8
Semesan, 2 hours	103	98	71	72.4	45	45.9	33	33.7	46.5
Semesan, 4 hours	103	98	68	69.4	50	51.0	38	38.7	68.3
Mercuric iodide:									
1 hour	104	99	84	84.8	79	79.8	73	73.9	221.3
2 hours	99	94	82	87.2	66	70.2	60	63.8	177.4
4 hours	80	76	72	94.7	64	84.2	57	75.0	226.1
Uspulun, 2 hours	123	117	84	71.8	75	64.1	62	52.9	130.0
Semesan Jr. dust	114	108	95	88.0	87	80.6	83	76.9	234.4
Semesan Jr. dust	154	146	135	92.4	121	82.9	104	71.2	209.6
Hot water:									
14 minutes, 50°C	81	77	73	94.8	65	84.4	62	80.5	250.0
16 minutes, 50°C	99	98	63	98.0	91	92.9	89	90.8	294.8
18 minutes, 50°C	53	47	44	93.6	31	66.0	25	53.2	131.3

Nine-months-old Seed

Check	48	46	20	43.5	16	43.5	9	19.6	0
Check	123	117	45	38.5	17	14.5	2	1.7	0
Average								10.7	
Mercuric chloride	44	42	30	71.4	26	61.9	23	54.8	412.1
Semesan Jr. dust	54	54	54	100.0	48	88.9	46	85.2	696.3
Semesan, 1 hour	65	65	64	98.5	43	66.2	40	61.5	474.8
Semesan, 2 hours	76	72	59	81.9	45	62.5	22	30.6	186.0
Semesan, 4 hours	47	45	26	57.8	23	51.1	13	28.9	170.1
Mercuric iodide:									
2 hours	59	56	48	85.7	40	71.4	16	28.6	164.5
4 hours	52	49	42	85.7	33	67.3	15	30.6	186.0
Hot water:									
16 minutes, 50°C	66	63	63	100.0	63	100.0	63	100.0	834.6
25 minutes, 50°C	51	49	43	87.8	41	83.7	33	67.3	529.0
30 minutes, 50°C	65	61	58	95.1	54	88.5	47	77.0	619.6

One-month-old Seed

Check	94	89	52	58.4	42	47.2	21	23.6	0
Check	68	65	49	75.4	31	47.7	21	32.3	0
Average								28.0	
Mercuric chloride	61	58	46	79.3	31	53.4	19	32.8	17.1
Semesan, 1 hour	66	63	47	74.6	35	55.6	18	28.6	0.2
Semesan, 2 hours	67	64	38	59.4	32	50.0	15	23.4	— 16.5
Semesan, 4 hours	56	53	34	64.2	31	58.5	19	35.8	27.9
Mercuric iodide:									
2 hours	69	66	55	83.3	42	63.6	24	36.4	30.0
4 hours	78	74	48	64.9	42	56.8	35	47.3	68.6
Semesan Jr. dust	84	80	61	76.3	53	66.3	39	48.8	74.3
Semesan Jr. dust	64	61	55	90.2	50	82.0	39	63.9	128.2
Hot water:									
14 minutes, 50°C	55	52	47	90.4	42	80.8	39	75.0	167.8
25 minutes, 50°C	65	62	53	85.5	49	79.0	47	75.8	170.7

SUMMARY OF 1924 SEASON'S RESULTS.

TREATMENT	PERCENTAGE INCREASE OF HEALTHY PLANTS				
	3-year-old seed	2-year-old seed	9-months-old seed	1-month-old seed	Average
Checks	0	0	0	0	0
Mercuric chloride, 0.1 per cent, 0.5 hour	44	179	412	17	163
Mercuric iodide:					
0.05 per cent, 1 hour	——	221	——	——	221
0.05 per cent, 2 hours	——	177	165	30	124
0.05 per cent, 4 hours	——	226	186	69	160
Semesan, 0.25 per cent, 1 hour	——	88	475	0	188
Semesan, 0.25 per cent, 2 hours	68	47	186	— 17	71
Semesan, 0.25 per cent, 4 hours	14	68	170	28	70
Uspulun, 0.25 per cent, 2 hours		130			130
Semesan Jr. dust	58	234, 210 } 222	696	74, 128 } 101	269
Hot water:					
14 minutes, 50°C	——	250	——	168	209
16 minutes, 50°C	112	295	835	——	414
18 minutes, 50°C	——	131	——	——	131
20 minutes, 50°C	70	290	——	——	180
25 minutes, 50°C	110	——	529	171	270
30 minutes, 50°C	——	——	620	——	620

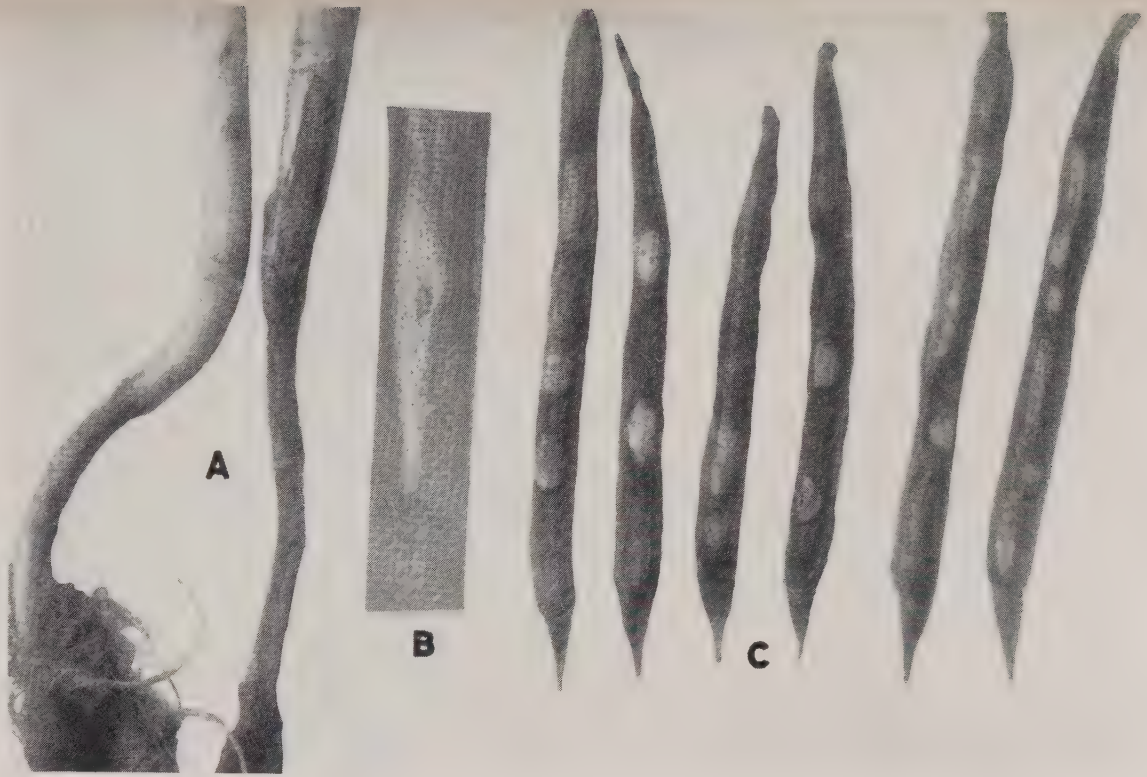

PLATE I.—BLACK-LEG INFECTIONS ON A YOUNG PLANT, MATURE SEED PODS, AND SEED STALK.

A, the plant to the left shows "wire stem" type of injury. Note the blackening and pinching in of the stem just above the roots. This is often confused by growers with black-leg which is shown in the plant at the right. The black-leg lesion, however, is higher on the plant and is distinguished by the presence of black dot-like pycnidia. B, black-leg lesions on seed stalk. These are more easily seen when inspecting seed plantings than are the pod lesions. In practise they can often be located 10 to 15 feet away, while pod spots are difficult to see from more than a third this distance. C, mature seed pods with black-leg lesions. At this stage the appearance of these spots is very distinctive. The pod itself is brown, the lesion ash grey, and the pycnidia are black.

PLATE II.—*Above*, CROP GROWN FROM UNTREATED BLACK-LEG INFECTED SEED. *Below*, THE SAME SEED AS SHOWN ABOVE, BUT TREATED WITH MERCURIC CHLORIDE BEFORE SOWING.

PLATE III.—*Above*, YIELD OF CABBAGE FROM, A AND D, UNTREATED CHECK PLATS AS IN PLATE II; B, HOT WATER TREATMENT PLAT AS BELOW; AND C, MERCURIC CHLORIDE TREATMENT PLAT AS IN PLATE II. (From 1924 experiments.)

Below, THE SAME SEED AS THAT SHOWN IN PLATE II HOT WATER TREATED BEFORE SOWING.

PLATE V.—THE SAME FIVE STRAINS AS SHOWN IN PLATE IV GROWN FROM THE SAME SEED HOT WATER TREATED. (From 1927 experiments.)

Semesan treated seed. Passing on to the field plats of this year, counts of healthy and diseased plants were made at intervals thru the growing season and in this way the progress of the disease was followed. The results are given in Table 20.

DISCUSSION OF 1924 FIELD RESULTS

The weather conditions in 1924 were favorable for the spread and development of the disease, and consequently there was an abundance of infection. Check plats of healthy seed sown in the seedbed and planted in the field remained 100 per cent healthy and gave definite proof that there was no soil infection or spread of disease from one plat to another, either of which would make it impossible to attempt conclusions as to the effectiveness of the seed treatments. The variability of the disease counts where the same or similar seed treatments were used is exactly what must be expected with a disease of this nature and with the small number of plants employed. The infection is never uniform and in natural field outbreaks it is usual to see 100 healthy plants consecutively, and in the next 100 perhaps 60 will be dead or dying. Consequently, in drawing conclusions, it is safe to deal only in averages.

Considering the average results, it appears that (a) mercuric chloride, which is the standard material now recommended, gave as good disease control as any other chemical soaking treatment, while Semesan gave the poorest results. (b) Semesan Jr. dust gave extremely good disease control. (c) Hot water treatments as a class gave the best results, and the shorter hot water treatments appeared to be very effective.

On the basis of the season's experience, it was decided that the next year disease counts would be taken in the field plats only at the end of the season, and every effort would be made to obtain more critical comparisons by means of greater plat replication.

RESULTS OF FIELD EXPERIMENTS IN 1925

The previous year's work indicated that the heat form of treatment was very effective but that the dust treatment gave surprisingly good results. In 1925 it was planned (a) to test a large number of dust and liquid seed treatment preparations, (b) to compare more thoroly dust and heat treatments and to try a combined heat and dust treatment, and (c) to make a careful test of the relative efficiency of the best forms of seed treatment.

Considering first the general comparison of dust and liquid chemical treatments, the procedure in treating small lots of seed with dust was to add the material to the seed a little at a time, using a pin head for a shovel and shaking the seed thoroly in an envelope. After the seed was thoroly coated, the excess dust was removed by passing

TABLE 21.—COMPARISON OF DUST AND LIQUID CHEMICAL TREATMENTS FOR BLACK-LEG OF CABBAGE IN FIELD PLATS.

TREATMENTS	NUMBER BLACK-LEG INFECTED PLANTS FOUND IN SEEDBED	FIELD COUNTS		PERCENTAGE INCREASE OR DECREASE IN HEALTHY PLANTS DUE TO TREATMENT
		Black-leg infected plants	Healthy plants	
Check	7	18	22	——
	6	19	21	——
Average	6.5	18.5	21.5	——
Dust treatments:				
Copper carbonate (Corona)	6	10	30	39.53
(Ortho)	1	11	29	34.88
Bayer dust	11	19	21	— 2.33
Semesan Jr.	2	6	34	58.14
du Pont No. 12	4	31	9	—58.14
du Pont No. 18	5	13	27	25.58
du Pont No. 19-B	3	8	32	48.84
du Pont No. 33	3	9	31	44.19
du Pont No. 34	4	18	22	2.33
Germisan No. 225	3	30	10	—53.49
Germisan No. 225–5	2	20	20	— 6.98
Germisan No. 225–3	4	23	17	—20.93
Saccharin Fab. No. 175	7	9	31	44.19
Saccharin Fab. No. 125	7	29	11	—48.84
Saccharin Fab. A. Z. 3	6	13	27	25.58
Liquid treatments:				
Mercuric chloride, 0.1 per cent, ½ hour	0	10	30	39.53
Semesan, 0.25 per cent, 2 hours	13	27	13	—39.53
Uspulun, 0.25 per cent, 2 hours	1	5	35	62.79
Germisan, 0.25 per cent, 2 hours	0	1	39	81.40
Bayer Compound, 25 per cent, 2 hours	0	4	36	67.44
du Pont No. 12	2	1	39	81.40
du Pont No. 18	3	16	24	11.63
Hexylresorcinol, 0.1 per cent, 2 hours	5	9	31	44.19
Metaphen, 0.1 per cent, 2 hours	1	5	35	62.79
Hot water treatments:				
18 minutes at 50°C	1	3	37	72.09
25 minutes at 50°C	0	1	39	81.40

the seed over a fine-mesh sieve. Seed lots were treated May 1 and sown May 28. The disease appeared in the seedbed plats prior to transplanting, and consequently seedbed counts were taken. Field plats of 40 apparently sound plants were also set from each seedbed plat and the data on the number of diseased and healthy plants in these lots recorded on November 10. The results secured in the seedbed and field plats are given in Table 21.

Comparing the dust treatments only, the greatest reduction in the amount of disease was secured with Semesan Jr. Many of the dust plats, however, showed more disease than the untreated checks, and the results in general were poor. Of the liquid soaking treatments, Germisan and du Pont No. 12 controlled the disease satisfactorily; Uspulun, Bayer Compound, and Metaphen were next in effectiveness, giving fair control; Hexyresorcinol and mercuric chloride were a little less effective; while Semesan seemed to favor disease development. The heat treatments were both quite effective, 25 minutes appearing slightly better than 18 minutes.

COMBINED HEAT AND CHEMICAL TREATMENT

The fact that seed can be double treated, using both heat and chemical, has been recognized by others. Müller, Molz, and Müller (5) gave wheat a preliminary treatment with Germisan, Kalimat, or formalin followed by a 10-minute dip in water at 52°C. They concluded that a combined treatment of this sort was effective against bunt (*Tilletia tritici* (Bjerk.) Wint.) and loose smut (*Ustilago tritici* (Pers.) Rostr.) and was a practical possibility.

Rodenhiser and Stakman (8) varied this procedure by using solutions of Uspulun, Semesan, and Germisan at 45°C, and they secured control of loose smut of wheat (*U. tritici* (Pers.) Rostr.) and barley (*U. nuda* (Jens.) Kell. & Sw.) and the barley stripe disease (*Helminthosporium gramineum* Rabh.).

The writer has previously noted the results from certain combined heat and chemical treatments in laboratory tests. (See Table 15.) The matter was now subjected to a well replicated field test. The procedure followed was, first, to treat seed for 25 minutes at 50°C and then, after the seed was dry, part was dusted with Semesan Jr. Untreated seed also was dusted, so that three forms of treatment were represented, *viz.*, (a) hot water only, (b) hot water plus Semesan Jr. dust, and (c) Semesan Jr. dust only. The seed was sown in the usual way. No notes on disease could be taken during the plant bed

TABLE 22.—COMPARISON OF COMBINED HOT WATER AND DUST TREATMENT WITH HOT WATER AND DUST USED SINGLY FOR BLACK-LEG IN CABBAGE.

TREATMENT	SEED LOT	DATE SOWN	NUMBER BLACK-LEG INFECTED PLANTS	NUMBER HEALTHY PLANTS	AVERAGE PERCENTAGE INCREASE IN HEALTHY PLANTS DUE TO TREATMENT
Hot water, 25 minutes 50°C	203	May 16	3	27	
	Stock Red	May 16	4	26	
	203	May 26	3	27	
	206	May 16	1	29	
	207	May 16	4	26	
	207	May 26	3	27	
	203	May 16	6	24	
	Stock Red	May 16	10	20	
	203	May 26	7	23	
	206	May 16	1	29	
	207	May 16	4	26	
	207	May 26	5	25	
Average per plat			4.25	25.75	83.93
Hot water-dust, 25 minutes 50°C plus Semesan Jr. dust	203	May 16	4	26	
	Stock Red	May 16	3	27	
	203	May 16	5	25	
	206	May 16	0	30	
	207	May 16	7	23	
	207	May 26	3	27	
	203	May 16	3	27	
	Stock Red	May 16	2	28	
	203	May 26	4	26	
	206	May 16	4	26	
	207	May 16	5	25	
	207	May 26	4	26	
Average per plat			3.66	26.30	87.86
Semesan Jr. dust	203	May 16	17	13	
	Stock Red	May 16	12	18	
	203	May 26	8	22	
	206	May 16	16	14	
	207	May 16	15	15	
	207	May 26	21	9	
	203	May 16	9	21	
	Stock Red	May 16	14	16	
	203	May 26	10	20	
	206	May 16	8	22	
	207	May 16	16	14	
	207	May 26	23	7	
Average per plat			14.08	15.90	13.57
Checks	203	May 16	19	11	
	Stock Red	May 16	21	9	
	203	May 26	8	22	
	206	May 16	19	11	
	207	May 16	10	20	
	207	May 26	19	11	
Average per plat			16	14	0

period because there was no apparent disease development, and at transplanting time all of the lots looked equally good. The field plats, however, soon began to show evidences of black-leg, and at the end of the season the data recorded in Table 22 were taken.

In this experiment the dust treatment gave practically no disease control, a complete reversal of the results secured the previous year and given in Table 20. The hot water treatment alone was as effective as the combined hot water and dust treatment; and in view of the excellent control given by the single treatment, there appeared little reason for considering the double process.

In the preceding experiments the data were taken in the form of counts of healthy and sick plants. The growers, however, think in terms of yields, and so in the following tests attention was paid to yields as well as disease counts. Table 23 gives the results of an experiment conducted at the Vegetable Research Farm at Riverhead in 1925. Each treatment was represented by five plats of 25 plants each with a double number for the untreated check. Records were taken of the number of plants heading, number diseased, and weight of cabbage cut.

There was a very light development of black-leg, and under these conditions mercuric chloride, Uspulun, Germisan, and hot water all gave about equally good control. Semesan dust treatment, however, resulted in more disease than no treatment, indicating again that dust cannot be depended upon. Considering the data on number of plants headed and pounds of cabbage cut, the hot water and Germisan treatments appeared to be distinctly the best.

A similar experiment was conducted at Farmingdale on the grounds of the State Institute of Applied Agriculture with the cooperation of Prof. S. Gray in 1925. Treatments were compared as follows:

1. The standard hot water treatment, consisting of 25 minutes soaking in water at 50°C.

2. The standard mercuric chloride soaking treatment, using a 0.5 hour soak in a 1–to–1000 solution.

3. An organic mercury dust, i. e., Semesan Jr.

4. An organic mercury soaking treatment, i.e., Metaphen, 0.1 per cent for 2 hours.

The seed treated was severely diseased red cabbage. All lots germinated well and, up to the time of transplanting, all grew equally well. After transplanting, however, it developed that some lots required more resetting than others. A record was kept of the total

TABLE 23.—FIELD COMPARISON OF SEED TREATMENTS FOR BLACK-LEG IN CABBAGE IN 1925.

	Plat number										Total	Average per plat
	1	2	3	4	5	6	7	8	9	10		
Untreated Check												
Number plants headed	15	12	12	11	4	4	12	15	11	13	109	10.9
Number not headed	7	9	11	12	15	19	10	10	10	12	115	11.5
Number healthy	19	21	22	25	16	22	22	26	21	25	219	21.9
Number diseased	3	4	2	2	9	3	2	0	2	2	29	2.9
Number missing	5	2	3	0	2	2	3	1	4	0	22	2.2
Number cut	6	4	5	3	1	0	3	1	2	5	30	3.0
Weight, pounds	20.6	9.0	12.5	14.1	2.1	6	8.3	4.3	2.7	14.9	88.5	8.9
Semesan Dust												
Number plants headed	9	6	7	16	13						51	10.2
Number not headed	13	11	9	4	3						40	8.0
Number healthy	20	18	15	23	16						92	18.4
Number diseased	6	9	8	2	11						36	7.2
Number missing	1	0	4	2	0						7	1.4
Number cut	3	1	0	7	4						15	3.0
Weight, pounds	7	3	0	17	6.1						33.1	6.6
Mercuric Chloride, 0.1 per cent, 0.5 Hour												
Number plants headed	8	11	11	12	19						61	12.2
Number not headed	16	13	12	11	6						58	11.6
Number healthy	24	27	24	23	26						124	24.8
Number diseased	0	0	0	0	0						0	0
Number missing	3	0	7	4	1						15	3.0
Number cut	4	4	4	5	7						24	4.8
Weight, pounds	12.5	11.3	13.8	7.7	15.5						60.8	12.2

Uspulun 0.25 per cent, 2 Hours												
Number plants headed	9	7	12	16	21						65	13.0
Number not headed	18	21	12	14	5						70	14.0
Number healthy	27	27	24	27	26						131	26.2
Number diseased	0	0	2	0	0						2	0.4
Number missing	0	0	1	0	1						2	0.4
Number cut	2	4	3	8	6						23	4.6
Weight, pounds	2.8	12.6	12.8	18.7	14.3						61.2	12.2
Germisan, 0.25 per cent, 2 Hours												
Number plants headed	14	15	15	13	17						74	14.8
Number not headed	9	9	9	8	7						42	8.4
Number healthy	21	24	22	21	21						109	21.8
Number diseased	3	0	2	1	5						11	2.2
Number missing	3	3	3	5	1						15	3.0
Number cut	7	7	8	6	7						35	7.0
Weight, pounds	19.5	20.0	26.3	14.5	18.0						98.3	19.7
Hot Water, 25 Minutes at 50°C												
Number plants headed	19	14	19	22	18						92	18.4
Number not headed	6	11	6	5	7						35	7.0
Number healthy	25	25	25	26	27						128	25.6
Number diseased	0	2	1	0	0						3	0.6
Number missing	2	0	1	1	0						4	0.8
Number cut	4	5	9	11	10						39	7.8
Weight, pounds	10.8	11.7	22.3	27.5	29.5						101.8	20.4

TABLE 24.—EFFECT OF VARIOUS SEED TREATMENTS ON NUMBER OF CABBAGE PLANTS HEADING, 1925.

TREATMENT*	NUMBER OF PLANTS SET ON JUNE 29	NUMBER OF REPLANTS		TOTAL NUMBER SET	PLANTS HEADED NOV. 10		PERCENTAGE INCREASE IN NUMBER PLANTS HEADED DUE TO TREATMENT
		July 15	July 25		Number	Per cent	
Checks	210	69	66	345	50	14.50	0
Hot water, 25 minutes at 50°C	210	16	13	239	191	79.91	451.10
Mercuric chloride, 0.1 per cent, 30 minutes	210	106	103	419	80	19.09	31.66
Semesan Jr. dust	210	46	43	299	75	25.08	72.97
Metaphen, 0.1 per cent, 2 hours	210	41	43	294	108	36.73	153.10

*Seven plats to each treatment.

TABLE 25.—EFFECT OF VARIOUS SEED TREATMENTS ON WEIGHT OF CABBAGE AND NUMBER OF HEADS CUT.

PLAT NO.	POUNDS OF CABBAGE CUT	NUMBER OF HEADS CUT	PERCENTAGE INCREASE IN WEIGHT
	Untreated Checks		
1	26.6	11	
2	2.8	2	
3	22.0	7	
4	20.0	9	
5	3.2	2	
6	3.0	2	
7	4.2	1	
Totals	81.8	34	0
	Hot Water, 25 Minutes at 50°C		
1	60.0	23	
2	48.0	18	
3	67.5	26	
4	34.8	15	
5	38.7	16	
6	53.5	20	
7	58.0	23	
Totals	360.5	141	339.9
	Mercuric Chloride, 0.1 Per cent, 30 minutes		
1	11.7	6	
2	28.3	10	
3	20.0	8	
4	26.0	10	
5	3.7	3	
6	18.5	7	
7	15.5	6	
Totals	123.7	50	51.1
	Semesan Jr. Dust		
1	3.0	2	
2	19.7	8	
3	11.5	7	
4	15.8	8	
5	28.8	11	
6	24.1	9	
7	39.5	13	
Totals	142.4	58	73.9
	Metaphen, 0.1 Per cent, 2 Hours		
1	30.2	14	
2	13.0	7	
3	8.0	4	
4	24.0	10	
5	37.0	13	
6	48.3	21	
7	22.5	10	
Totals	183.0	79	123.4

number of plants set in each plat. In the fall, counts were made of the number of plants headed, the weight of the heads cut, and the number of heads cut in each plat. These records appear in Tables 24 and 25.

The disease was virulent and conditions favored a critical test of the effectiveness of the treatments. Under these conditions the hot water treatments, judged either by percentage of plants heading or by weight of heads cut, gave by far the best results. The organic mercury gave distinctly better results than the mercuric chloride or dust, but all three failed to give satisfactory disease control.

The foregoing field experiments of 1924 and 1925 were conducted on the plat basis. Heavily infected seed was used and everything was done to insure a thoro and fair test of the various forms of seed treatment. The results have been uniformly good with the hot water treatment and uncertain with other forms of treatment. The next question considered was, What would be the result of treating the farmer's own seed in place of these specially selected lots of highly diseased seed?

The writer has attempted to answer this question in two ways.

First, by treating seed for a large number of farmers and thus getting a general reaction. As has been mentioned, during the seasons of 1925, 1926, and 1927, a regular treating station was maintained and large numbers of growers brought in cauliflower, brussels sprouts, and cabbage seed. These stocks were sampled; the samples tested for germination before and after treatment; and, if the sample tests were satisfactory, the main lots of seed were treated. The growers took their seed home immediately after treatment and dried it themselves. The results of this work have been extremely favorable, growers reporting that their crops were more nearly free from disease than ever before. As a consequence, there are now large numbers of growers who would not think of sowing anything but hot water treated seed.

In addition to this, a second test of the value of hot water treatment to the average grower was made in the following way. All brussels sprouts seed is locally grown and hence easy to keep track of so, as the growers brought it in, samples were taken before and after treating. These samples were then planted in separate seedbeds; and when the plants were of the proper size, rows were set from each seed strain of both treated and untreated seed. In this way, each

TABLE 26.—COMPARISON OF EFFECT ON BLACK-LEG INFECTION OF HOT WATER TREATED AND UNTREATED COMMERCIAL BRUSSELS SPROUTS SEED AT RIVERHEAD IN 1925.

SOURCE OF SEED	NUMBER OF PLANTS BLACK-LEG INFECTED		NUMBER OF HEALTHY PLANTS		PERCENTAGE OF HEALTHY PLANTS	
	Treated seed	Untreated seed	Treated seed	Untreated seed	Treated seed	Untreated seed
George Hallock	3	13	77	67	96.25	83.75
Harold King	0	34	80	46	100.00	57.50
Edwin King	0	19	80	61	100.00	76.25
Paul Edwards	2	15	78	65	97.50	81.25
J. W. Cooper No. 2	4	18	76	62	95.00	77.50
George Howard	1	2	79	78	98.75	97.50
H. S. Duvall	2	13	78	67	97.50	83.75
Peter Hand	3	14	77	66	96.25	82.50
Wm. Haberman	3	24	77	56	96.25	70.00
J. W. Cooper No. 1	1	22	79	58	98.75	72.50
Totals	19	174	781	626	976.25	782.50
Averages	1.9	17.4	78.1	62.6	97.63	78.25

TABLE 27.—COMPARISON OF EFFECT ON BLACK-LEG INFECTION OF HOT WATER TREATED AND UNTREATED COMMERCIAL BRUSSELS SPROUTS SEED AT FARMINGDALE IN 1925.

SOURCE OF SEED	NUMBER OF PLANTS BLACK-LEG INFECTED		NUMBER OF HEALTHY PLANTS		PERCENTAGE OF HEALTHY PLANTS	
	Treated seed	Untreated seed	Treated seed	Untreated seed	Treated seed	Untreated seed
George Hallock	3	53	54	4	94.74	7.02
Harold King	2	51	55	6	96.49	10.53
Edwin King	0	50	57	7	100.00	12.28
Paul Edwards	0	54	57	3	100.00	5.26
J. W. Cooper No. 2	4	42	53	15	92.98	26.32
George Howard	2	55	55	2	96.49	3.51
H. S. Duvall	3	48	54	9	94.74	15.79
Peter Hand	1	52	56	5	98.25	8.77
Wm. Haberman	0	55	57	2	100.00	3.51
J. W. Cooper No. 1	2	53	55	4	96.49	7.02
Totals	17	513	553	57	970.18	100.01
Averages	1.7	51.3	55.3	5.7	97.02	10.00

strain of seed was represented by a plat grown from treated seed and also by a plat grown from untreated seed.

In 1925, 10 strains of seed, treated and untreated, were sown in two separate seedbeds at Riverhead. On the same day, plants were taken from this bed and one series of plats set out at Riverhead in rather heavy soil and the other on the farm of the State Institute of Applied Agriculture, Farmingdale, on light soil. The results of the two plantings are given in Tables 26 and 27.

In the Riverhead planting, the effects of the disease were noticeable but by no means disastrous. The same seed stock set out at Farmingdale showed almost a 100 per cent loss from black-leg in the untreated seed. The uniformly vigorous and even appearance of the plants growing from the treated seed was commented on by many observers. A similar test with similar results was conducted at the farm of Mr. Frank Thilberg in 1925, and again at Riverhead in 1926. The results of these tests are given in Tables 28 and 29.

In another series of tests using samples of sprouts seed received from local growers, plantings from treated and untreated seed were again compared. Instead of making counts of diseased and healthy plants, however, plats were scored by a committee of local growers. These men paid no attention to disease counts. Instead, they scored each lot of plants on the following basis:

25 points for uniformity and vigor of plants as a whole.
30 points for the crop on the basis of quality.
45 points for the crop on the basis of quantity.

It was believed that such a scoring system would measure the value of the seed treatment in dollars and cents. The judges scored the rows by number, and they did not know the strain names nor whether the plants were grown from treated or untreated seed. The first test of this sort was conducted at the farm of William Haberman in 1925. The results of this experiment are given in Table 30.

RESULTS OF FIELD EXPERIMENTS IN 1926

This experiment was continued in 1926, and again samples of sprouts seed were saved as the growers brought in their stocks for treatment at the Vegetable Research Farm. Twenty-six separate lots of seed were included in the test. These lots were divided among three growers, each of whom sowed the treated and untreated samples in separate seedbeds. All seed was sown about the first of June, and field plats were set out about July 20. The plants were set by

TABLE 28.—COMPARISON OF TREATED AND UNTREATED BRUSSELS SPROUTS SEED AT RIVERHEAD IN 1926.

SOURCE OF SEED	NUMBER OF PLANTS BLACK-LEG INFECTED		NUMBER OF HEALTHY PLANTS		PERCENTAGE OF HEALTHY PLANTS	
	Treated seed	Untreated seed	Treated seed	Untreated seed	Treated seed	Untreated seed
H. S. Duvall No. 1	1	7	23	17	95.8	70.8
Peter Hand	2	8	22	16	91.7	66.7
George Hallock	0	4	24	20	100.0	82.3
Wm. Haberman	0	6	24	18	100.0	75.0
Jos. Zimnowski	0	10	24	14	100.0	58.3
Philip Burke	0	12	24	12	100.0	50.0
H. S. Duvall No. 2	2	7	22	17	91.7	70.8
J. F. Douglass	0	6	24	18	100.0	75.0
E. Wiggans	0	16	24	8	100.0	33.3
George Howard	2	9	22	15	91.7	62.5
Totals	7	85	233	155	970.9	644.7
Averages	0.7	8.5	23.3	15.5	97.09	64.47

TABLE 29.—COMPARISON OF TREATED AND UNTREATED BRUSSELS SPROUTS SEED AT FRANK THILBERG'S IN 1925.

SOURCE OF SEED	NUMBER OF PLANTS BLACK-LEG INFECTED		NUMBER OF HEALTHY PLANTS		PERCENTAGE OF HEALTHY PLANTS	
	Treated seed	Untreated seed	Treated seed	Untreated seed	Treated seed	Untreated seed
Paul Edwards	4	90	93	7	95.9	7.2
Ralph Sterling	2	89	95	9	97.9	9.2
	10	75	87	22	89.7	22.7
J. W. Cooper	3	28	94	69	96.9	71.1
Wm. Haberman	15	41	82	56	84.5	57.7
C. Haberman	4	20	94	77	95.9	79.4
N. Douglass	6	33	91	64	93.8	66.0
E. H. King	15	44	92	53	86.0	54.6
George Howard	16	71	81	16	83.5	18.4
H. S. Duvall	3	25	94	72	96.9	74.2
Peter Hand	1	11	96	86	99.0	88.7
George Hallock	8	29	91	68	91.9	70.1
Totals	87	556	1,090	599	1,111.9	619.3
Averages	7.3	46.3	90.8	49.9	92.7	51.6

TABLE 30.—COMPARISON OF SPROUTS STRAINS GROWN FROM TREATED AND UNTREATED SEED AT WM. HABERMAN'S IN 1925.

SOURCE OF SEED	VIGOR AND UNIFORMITY: 25 POINTS		QUALITY OF YIELD: 30 POINTS		QUANTITY OF YIELD: 45 POINTS		TOTAL POINTS	
	Treated seed	Untreated seed	Treated seed	Untreated seed	Treated seed	Untreated seed	Treated seed	Untreated seed
B. D. Latham, Orient	24	10	29	5	45	25	98	40
Paul Edwards, Orient	24	11	30	5	45	25	99	41
Paul Edwards, Orient	24	10	30	4	45	24	99	38
Ralph Sterling, Cutchogue	15	1	10	1	12	1	37	3
Ralph Sterling, Cutchogue	14	2	5	1	10	1	29	4
J. W. Cooper, Mattituck	23	22	27	10	30	16	80	48
J. W. Cooper, Mattituck	22	21	27	9	30	14	79	44
Wm. Haberman, Orient	21	4	28	3	30	18	79	25
C. Haberman, Mattituck	22	4	27	3	29	18	78	25
J. Douglass, Orient	22	4	27	3	28	18	77	25
E. King, Orient	23	4	27	3	30	18	80	25
George Howard, Mattituck	22	5	27	3	27	17	76	25
George Hallock, Orient	23	7	27	5	40	18	90	30
H. S. Duvall, Orient	22	4	27	2	35	15	84	21
H. King, Orient	24	3	27	1	40	1	91	5
Wm. Karcher, Orient	23	22	27	10	39	2	89	34
Peter Hand, Cutchogue	23	22	27	10	35	2	85	34
Peter Hand, Cutchogue	23	21	27	9	35	2	85	32
Totals	394	177	456	87	585	235	1435	499
Averages	22	10	25	5	33	13	80	28

machine and each sowing of treated and untreated seed was represented by a row the entire length of the field. The rows were labeled by number only and no information as to the identity of different lots was given out prior to the scoring. Late in October, the plats were scored by a committee of growers on the following basis:

30 points for vigor and uniformity
35 points for quality of crop
35 points for quantity of crop

The results are given in Table 31.

TABLE 31.—COMPARISONS OF TREATED AND UNTREATED SPROUTS SEED IN 1926.

LOCATION OF PLATS	SEED STRAIN USED	TOTAL POINTS SCORED	
		Treated seed	Untreated seed
Hallock Farm, Orient	George Howard	59	22
	Wm. Haberman	64	34
	Wm. Karcher	66	19
	George Hallock	75	17
	Peter Brown	52	20
	Peter Hand No. 1	60	31
	Peter Hand No. 2	49	40
	Jos. Zimnowski	57	43
	J. F. Douglass	80	48
	H. S. Duvall	68	40
Sterling Farm, Cutchogue	H. M. Reeve	63	65
	Jos. Zimnowski	52	57
	H. S. Duvall	86	38
	George Hallock	63	38
	Wm. Haberman	68	73
	Peter Hand	60	39
	E. Wiggins	60	61
	R. Sterling	73	75
	Frank Young	50	47
	T. Gadomski	74	68
Kirkup Farm, Mattituck	Peter Nartowicz	47	16
	John Moisa	63	16
	John Sledjieski	56	16
	Jacob Popleski	59	18
	John Trycowski	45	21
	George Howard No. 1	45	16
	George Howard No. 2	43	19
	Peter Hand	65	18
	H. S. Duvall	55	25
	Philip Burke	71	32
Totals		1,828	1,072
Averages		61	36

The results of the two-year test show that there was plenty of disease in the commercial sprouts seed stocks. Of course, owing to the fact that all untreated stocks were sown side by side, there was opportunity for the disease to spread from one lot to another in the bed, and for this reason, it is not to be supposed that all the untreated seed stocks were disease carriers.

In the test at the Sterling Farm in 1926, the strains were sown in a single long row so that the only point of contact between the strains was at the ends. Under these conditions, there was practically no spread of disease from one lot of plants to another. Examination of the data will show that 7 of the 10 strains yielded as well untreated as treated, while the other 3 strains were very greatly improved by seed treatment. How well the heat treatment was able to remove the infection from diseased seed may be judged by the fact that, in this test, the Duvall strain scored the lowest of all, 38, when sown untreated and the highest of all, 86, when treated. On the whole, in 1925, the judges gave the untreated seed plantings 499 points and the treated 1,435 points. In 1926, the untreated seed received 1,072 and the treated seed 1,828 points.

Practically all of the growers represented by seed samples in these experiments, and scores of others in addition, have now been sowing hot water treated sprouts, cauliflower, and cabbage seed exclusively for two and in some cases three years. This seed was treated by the author, using the standard procedure here recommended. The reports of the results secured by these growers have been extremely favorable. In general they may be summed up under two heads, i. e., greater freedom from disease and more vigorous growing crops. The second presumably comes in part from the first. It may be confidently stated that at least 90 per cent of the growers who have tried planting hot water treated seed exclusively for one year have insisted on having nothing else in succeeding years.

EFFECT OF SEED TREATMENT ON VIGOR OF PLANTS

During the course of this work, the observation has been repeatedly made that hot water seed treatment gives a more vigorous lot of plants than does mercuric chloride seed treatment, and in some instances where this was true there was no evidence of a disease factor. Differences of this sort, while very important, are difficult to measure definitely, and furthermore they do not always manifest themselves.

One measure of the hardiness of the plants, however, is their ability to stand transplanting under unfavorable conditions. With

favorable conditions, of course, any sort of a plant lives. In 1926, one series of plats was set out on a very hot day in dry soil. It soon became apparent that considerable resetting would be necessary, so a strict account was kept of the number of plants reset with the results shown in Table 32.

TABLE 32.—EFFECT OF VARIOUS SEED TREATMENTS ON THE NUMBER OF PLANTS RESET UNDER UNFAVORABLE CONDITIONS IN 1926.

TREATMENT	NUMBER PLANTS RESET		
	July 15	July 30	Total
Checks—Series 1	13	10	23
Series 2	17	6	23
Semesan dust	12	6	18
Uspulun, 0.5 per cent, 2 hours	14	14	28
Germisan, 0.25 per cent, 2 hours	9	—*	—*
Mercuric chloride, 0.1 per cent, 0.5 hour	26	15	41
Hot water, 10 minutes, 55°C	11	3	14
Hot water, 25 minutes, 50°C	11	4	15

*No plants available.

Consideration of these figures shows that the plats from untreated seed and those from dusted and Uspulun treated seed behaved about alike. Those from mercuric chloride treated seed required almost twice as much replanting as the checks, and those from hot water treated seed only about three-fifths as much replanting as the checks.

All lots, it may be said, gave equally good stands in the plant bed except the Germisan treated plat, and this lot was omitted from consideration. Furthermore, these differences were not associated with disease differences, for there was ultimately much loss from black-leg in the check and dusted plats and very little in any of the others.

Similar results were secured in an experiment conducted at Farmingdale in 1925, the data of which are given in Table 24. Here again, conditions were unfavorable for transplanting and much replanting was necessary. The actual number of replants used was as follows:

Check (7 plats).....135 plants
Mercuric chloride treatment.....209 plants
Metaphen treatment..... 84 plants
Semesan Jr. dust..... 89 plants
Hot water treatment:..... 29 plants

These figures were not influenced by seed-borne disease because black-leg did not begin to kill plants until much later, and even

then did not kill as many plants in the mercuric chloride plats as in the untreated plats.

Seed treatment effects on the later plant growth may also be expressed in terms of yield. Thus, in the 1925 experiment reported in Table 23 it may be observed that the disease counts are low and that the mercuric chloride, Uspulun, Germisan, and hot water treatments gave equally good disease control. The plat averages for the checks (10 plats) and for the various treatments (5 plats each) are given in Table 33.

TABLE 33.—PLAT AVERAGES FOR A FIELD COMPARISON OF VARIOUS SEED TREATMENTS FOR BLACK-LEG IN CABBAGE IN 1925.

TREATMENT	NUMBER HEALTHY PLANTS	NUMBER PLANTS HEADED	NUMBER HEADS CUT	WEIGHT HEADS CUT, POUNDS
Check	21.9	10.9	3.0	8.9
Mercuric chloride	24.8	12.2	4.8	12.4
Uspulun	26.2	13.0	4.6	12.2
Germisan	21.8	14.8	7.0	19.7
Hot water	25.6	18.4	7.8	20.4

Here again we see that the mercuric chloride treated plats, tho showing little more disease than the heat treatments in this instance, were poorer than the hot water treated plats if judged either by number of plants headed, number of heads cut, or the weight of cabbage cut. The Germisan treatment shows none of these poor effects and has generally given results equal to the hot water treatment, but unfortunately it is liable to cause severe seed injury when used at 0.25 per cent for two hours and at a lesser strength or for a shorter time it failed to give good disease control.

Beneficial effects of hot water treatment on vigor of growth and on yield have been reported by many growers and are regarded by them as established facts. Certainly, it appears that in some instances the crop has been greatly improved by the heat treatment and that this effect has had no connection with disease control. Effects of this sort can only be referred to as stimulation. It should be emphasized that striking results of this nature are not regular in their occurrence.

EFFECT OF SEED TREATMENT ON GERMINATION

The writer has conducted a large number of experiments to determine the effect of various seed treatments on germination. The data accumulated are bulky and the work is as yet incomplete,

therefore a detailed account of the results will not be presented at this time. There is a very general impression that hot water treatment is likely to reduce germination, and consequently innumerable germination tests have been made during the past five years, both in the greenhouse and in the field.

These tests have shown that hot water treatments of from 20 to 30 minutes with a temperature of 50°C (122° F) do not appreciably reduce germination, providing the seed possesses strong germination to begin with and is sown soon after treatment. Seed injury becomes a factor when the seed is weak or when it is held for some time before planting.

Consequently, it is advisable to test seed for germination before treating to eliminate the weak stocks and to treat the seed as near planting time as is convenient. As the result of treating hundreds of seed lots for Long Island farmers, it may be stated that cauliflower, cabbage, and sprouts stocks germinating less than 60 per cent in a soil test are likely to give poor field stands and, furthermore, that it is better to treat seed not longer than three to four months ahead of planting. About 5 per cent of the seed brought in to the writer for treatment has been refused because of low germination. This may seem a small fraction, but a few bad results are all that are necessary to give a treatment a thoroly bad name.

Germination tests to determine the strength of a seed stock should be conducted in the greenhouse, sowing the seed in heat-sterilized soil. Blotter tests and various other forms of artificial germination tests are apt to give misleading results with cabbage, sprouts, and cauliflower seed.

The effect of various chemicals used in combination with the heat treatment has been given much study. The use of an organic mercury, either as a hot solution or as a dip or dust after hot water treatment, has been tested; also the value of salts which make the treating water more acid or more alkaline. Thus aluminum sulfate in very small amount will greatly increase the acidity of the water. The results to date fail to show any worth while gain, and not infrequently they show quite the reverse. In fact it may be stated that, in general, the use of chemicals in combination with hot water treatment increased seed injury.

DISCUSSION OF RESULTS

Considering first the investigations with chemical disinfectants, it is obvious that these materials vary greatly in effectiveness. The dust preparations are desirable because of ease of application, and in the 1924 field trials Semesan Jr. dust gave excellent black-leg control, better than any other chemical treatment dry or wet. The next year, however, Semesan Jr. and also Semesan gave practically no control of the disease, and similar results were secured in 1926, hence dust treatment with Semesan or Semesan Jr. is not to be recommended for black-leg. Numerous other dust preparations have been tested and none were found more effective. These results were confirmed in practise, for in 1925 several growers used Semesan dust on sprouts seed and secured practically no black-leg control and in some cases suffered very heavy losses from the disease.

Passing to the liquid treatments, it appears that of those tested Germisan alone gave distinctly better disease control than the old mercuric chloride treatment. It was necessary, however, to use Germisan in a 0.25 per cent solution for a two-hour soak to attain these results, and this treatment repeatedly caused severe seed injury, tho strong seed stocks sown at once were not affected. Owing to the danger of seed injury, treatment with Germisan at this strength cannot be recommended, while a weaker solution is no more effective than mercuric chloride in controlling black-leg.

Uspulun (0.25 per cent for two hours) was slightly more effective than mercuric chloride, tho the difference was not great. Semesan at the same strength and with the same exposure was very ineffective. Indeed in a number of tests Semesan liquid treatment actually seemed to increase the amount of disease.

The hot water treatments have consistently given good black-leg control. Using a temperature of 50°C (122° F), the treatment became increasingly effective as the exposure was increased up to 25 minutes, but an increase from 25 to 30 minutes gave no further gain. All exposures in excess of 15 minutes eliminated most of the infection, but even with 25- to 30-minute treatments there was a trace of disease remaining. The 25-minute treatment at 50°C has been tested on a large scale by treating seed stocks for farmers and has given uniformly good results. It does not seriously reduce the germination of one- and two-year-old seed stocks of good quality, but it cannot be recommended for old seed stocks or for those low in vital-

ity. The heat treatment is much less liable to cause seed injury than treatment for two hours with Germisan.

Effective hot water treatments have been worked out with temperatures of 55° and 60°C, equivalent to 131° and 140° F. Thus, 25 minutes at 50°C gave about the same results as 10 minutes at 55°C and 4½ minutes at 60°C. There is greater danger of seed injury with these higher temperatures, however, and these treatments are not as safe as the one of 25 minutes at 50°.

Dusting the seed after treating with hot water and drying appeared to have possibilities, since, in the first year's field work, Semesan Jr. dust gave satisfactory disease control when used alone. This was tried out in the field the next year, however, and the dust gave little control of black-leg and failed to increase the effectiveness of the hot water treatment. In view of the excellent control secured with hot water alone, the writer sees no reason for developing a combination heat and chemical treatment in so far as black-leg is concerned. The organic mercury chemical treatments, however, aid in securing a good stand by protecting the seed from decay after it is sown; and when such protection is needed, as in early spring, the hot water treated seed may be further processed either with liquid or dry disinfectant. The heat treatment, of course, destroys disease infection present on the seed but does not protect the seed from decay in the soil after sowing.

The comparative merits of the hot water and mercuric chloride treatments for black-leg have received much discussion from previous workers, and the writer's conclusion is that the hot water treatment must be given preference because it is effective in the field and the mercuric chloride often is not. Furthermore, there is evidence indicating that the heat treatment exercises a distinctly stimulating effect on subsequent plant growth, while the mercuric chloride treatment has a weakening effect.

The question of seed injury has always loomed large in any discussion of seed treatment by hot water, and the writer believes that this is proper. After conducting a community seed-treating plant for three years, it is concluded that by testing the seed before treating it the small percentage of stock that is low in vitality can be eliminated, with the result that the remainder can be processed without fear of serious injury. A treatment such as the hot water treatment should not be used by every farmer but rather should be operated under competent supervision. This supervision can usually be

supplied by the county agent. In general, it is more convenient and safer for growers to buy seed already treated. In localities where there is considerable demand this should be possible thru the establishment of a central treating plant.

It is interesting to compare the results obtained in these tests with those reported by Walker (10) and Cunningham (1). Walker concluded that the hot water treatment was completely effective in destroying seed-borne black-leg. He states that, "When complete eradication of the organism is desired even at the expense of some reduction in the percentage of germinable seeds hot water treatment at 122°F (50°C) for 30 minutes without presoaking is recommended." He considered that this treatment was too hazardous for general use and so preferred the mercuric chloride soaking process which he recognized, however, to be distinctly less effective.

Cunningham concluded that mercuric chloride was almost completely ineffective and the hot water treatment but little better. With respect to the organic mercurials he states that Uspulun, Germisan, and Semesan, 0.25 per cent for one hour, "had no appreciable effect on the fungus—unless a stimulatory one," and that, "a similar series in which the soaking was extended to two hours gave almost precisely the same results."

The experiments discussed here have been conducted on a much more extensive scale than those of either of the above investigators, and the conclusions reached apparently agree closely with those of Walker. No hot water treatment was found perfectly effective, but the marked superiority of this form of treatment over the mercuric chloride process was thoroly established. In the light of these results it is difficult to understand how Cunningham could find two hours' soaking in 0.25 per cent Germisan stimulatory to black-leg, for with us this treatment has repeatedly given excellent black-leg control, tho it cannot be recommended for general use owing to the fact that it often causes severe seed injury. Cunningham's conclusions regarding the ineffectiveness of Germisan and hot water treatments, however, appear to be drawn entirely from laboratory tests and consequently are open to question. Gassner (2), after bitter experience, concluded that laboratory methods of testing the chemotherapeutical efficiency of disinfectants may give little or no indication of their actual value in the field.

As we have seen the problem, it is to discover the simplest seed treatment which will control black-leg under field conditions. The

dust treatments are the simplest, but unfortunately they are not effective. The liquid chemical treatments are next in simplicity, but also are not effective if used in safe strengths. Hot water treatment is more difficult than either dust or liquid chemical, but our results confirm those obtained by others that it is effective in actual practise, tho it does not destroy 100 per cent of the disease. However, disease control measures as a whole would have to be thrown into the discard if forced to measure up to the 100 per cent standard and this would of necessity entail sacrifice of simplicity and safety of application. In practise, safety and simplicity are almost as important as effectiveness.

It is to be hoped that advances along chemical lines will make possible in the future a liquid soak or dry dust form of treatment that will be satisfactory against black-leg. Growers, however, should be warned not to pay attention to claims advanced for new materials unless these are supported by thoro tests of an exacting nature.

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